Meeting Minutes
Ad Hoc Committee on Amateur Radio Digital Communication
September 14-16, 1984

The following committee members and observers were present for all or part of the weekend's meetings:

Committee members:

Paul Rinaldo, W4RI (Chairman)
Marshall Quiat, AG0X (Board Liaison)
Den Connors, KD2S
Terry Fox, WB4JFI
Lyle Johnson, WA7GXD
Wally Linstruth, WA6JPR
Doug Lockhart, VE7APU
Hank Magnuski, KA6M
Paul Newland, AD7I
Eric Scace, K3NA

Observers:

Jon Bloom, KE3Z
Pete Eaton, WB9FLW
Alan Jones, G8WJM
Phil Karn, KA9Q
Hanspeter Kuhlen, DK1YQ (AMSAT-DL)
Harold Price, NK6K
Gwyn Reedy, W1BEL
John Sager, G8ONH (RSGB)
Ian Wade, G3NRW (BARTG)
Jeff Ward, K8KA

Friday, September 14

Although there was not a formal committee meeting on Friday, there was an orientation session for the foreign observers. Each of the people present introduced himself, and described the packet-radio projects he or his organization was involved in. Of special interest were descriptions of English and German packet activity presented by the Ian Wade, John Sager, and Hanspeter Kuhlen.

Following this, there were several hours of discussions and tutorials. Covered were: history of amateur packet radio, analysis of available TNCs, packet-radio repeaters, bulletin boards, packet radio via satellite, packet-radio meteor scatter, HF packet radio, introduction to networking, and a look into the future of amateur packet radio.

Packet Legal Issues

Perhaps the most interesting comments of the afternoon came from the European observers. Hanspeter and Ian noted that digipeating is illegal in their countries, and Hanspeter added that, in Germany, no two repeaters may be linked together. It follows that the first order of business for many European packeteers will be to petition their governing bodies for rule changes. In this context, the group discussed the U.S. rules and the pending ARRL petition for rules allowing automatic operation of stations engaged in digital communication.

Satellite Packet Radio

Harold Price and Hanspeter Kuhlen addressed packet radio and satellites. A breakdown of that discussion, by satellite, follows:

AO-10 has been used for some packet-radio experiments, including the operation of some attended teleports. The main problem with AO-10 is signal-to-noise ratio. The SNR attainable by a modest ground station is very near the threshold of operation of currently available modems. The SNR problem has two causes, spin modulation caused by a bent antenna (aggravated by bad satellite sun angles), and transponder AGC caused by stations running too much uplink power. It was agreed that AO-10 could be used for future automated teleports, if other stations using the transponder were more courteous, and when a more efficient modem is developed. Phil Karn and Ed Shrum are working on a PSK modem for PACSAT use, and this modem should also be an asset on AO-10.

PACSAT Is slated for a late 1986 or early 1987 launch, with the Space Shuttle being the desired launch vehicle. The satellite will have four 9600-baud packet channels, and will be store-and-forward "mailbox in the sky," rather than the common "repeater in the sky." PACSAT depends on the development of a PSK modem for use both in ground stations and in the spacecraft.

JAS-1 is the Japanese-built amateur satellite that will be launched sometime between 1985 and 1987, from a Japanese launch vehicle. Because the Japanese Space Agency requires that the satellite be professionally built, the final design for JAS-1 has already been turned over to NEC. The satellite will carry a traditional Mode-J transponder, and a packet-radio store-and-forward transponder using AX.25 link-layer protocol, and 1200-baud FSK modulation. Because the transponder will use 1200-baud FSK, it will be accessible to stations with no special modem or modified TNC. The use of AX.25 link-level on JAS-1 is a giant step toward worldwide packet-radio standardization.

Phase III C, if it exists, may have a packet-radio transponder. If a water-propelled kick motor is used for the satellite, space and power will be available to fly a packet transponder. Because Phase III satellites have long visibility times, no store-and-forward technology will be necessary. What is needed is a minimal digipeater drawing very low power, not relying on EPROMs or power-hungry HDLC chips. This may be a perfect application for the "software approach" to packet radio. It is necessary to note that only a package with the minimum in hardware and software could be flown.

AO11 DCE. The Data Communications Experiment is simply 128 kilobytes of RAM with uplink and downlink access. The DCE was primarily meant to supply a hardware and software test bed for PACSAT concepts. Secondarily, the DCE was to provide some communications services via a limited number of teleport stations throughout the world. These plans will have to be modified due to the failure of some components in the satellite command link. The DCE is being used to bypass the failed components. After the commissioning of a ground station in Los Angeles, DCE programmers will determine whether the DCE can be used simultaneously as a store-and-forward mechanism and as a satellite command link.

With two satellites in operation, and (at least) three more under consideration, the growth of wide-area packet networking will certainly depend on satellite links.

Saturday, September 15

The official meeting of the Digital Committee was called to order at 0955 on Saturday morning.

Future Committee Meetings

The first order of business was to choose meeting places and times for future Committee meetings. Wally Linstruth has reserved a meeting room for a Digital Committee meeting on November 11 tailgating the AMSAT Technical Symposium. The AMSAT symposium will be held on November 10, in Los Angeles, CA. Paul Rinaldo expressed concern that the Digital Committee budget might not be large enough to transport all Committee members to California for this meeting. There was then some discussion as to whether it would be necessary to have a full Committee meeting. Perhaps only small working groups or representatives of working groups will be required to attend. This was left open, pending a review of the budget.

For local arrangements concerning this meeting, contact: Wally Linstruth, WA6JPR, (213)542-3290 or (805)963-8694.

Hank Magnuski then started discussion of the Fourth ARRL Amateur Radio Computer Networking Conference. This conference is to be held in conjunction with the West Coast Computer Faire, in San Francisco, CA. The 1985 Faire will be held March 30, 31 and April 1, 2 at the Mosconi Convention Center in San Francisco. The presentation of conference papers will be on Saturday, March 30. A meeting of the full Digital Committee is planned for Sunday, March 31. Plans for the meeting and the forum will be finalized by Hank Magnuski.

Gwyn Reedy let it be known that, should any of the plans for the Computer Networking Conference fall through, the Conference could be moved to the Southeast Division Convention (Miami Hamfest), held on February 3, 1985. Gwyn also invited all Committee members and observers to take part in a packet-radio forum.

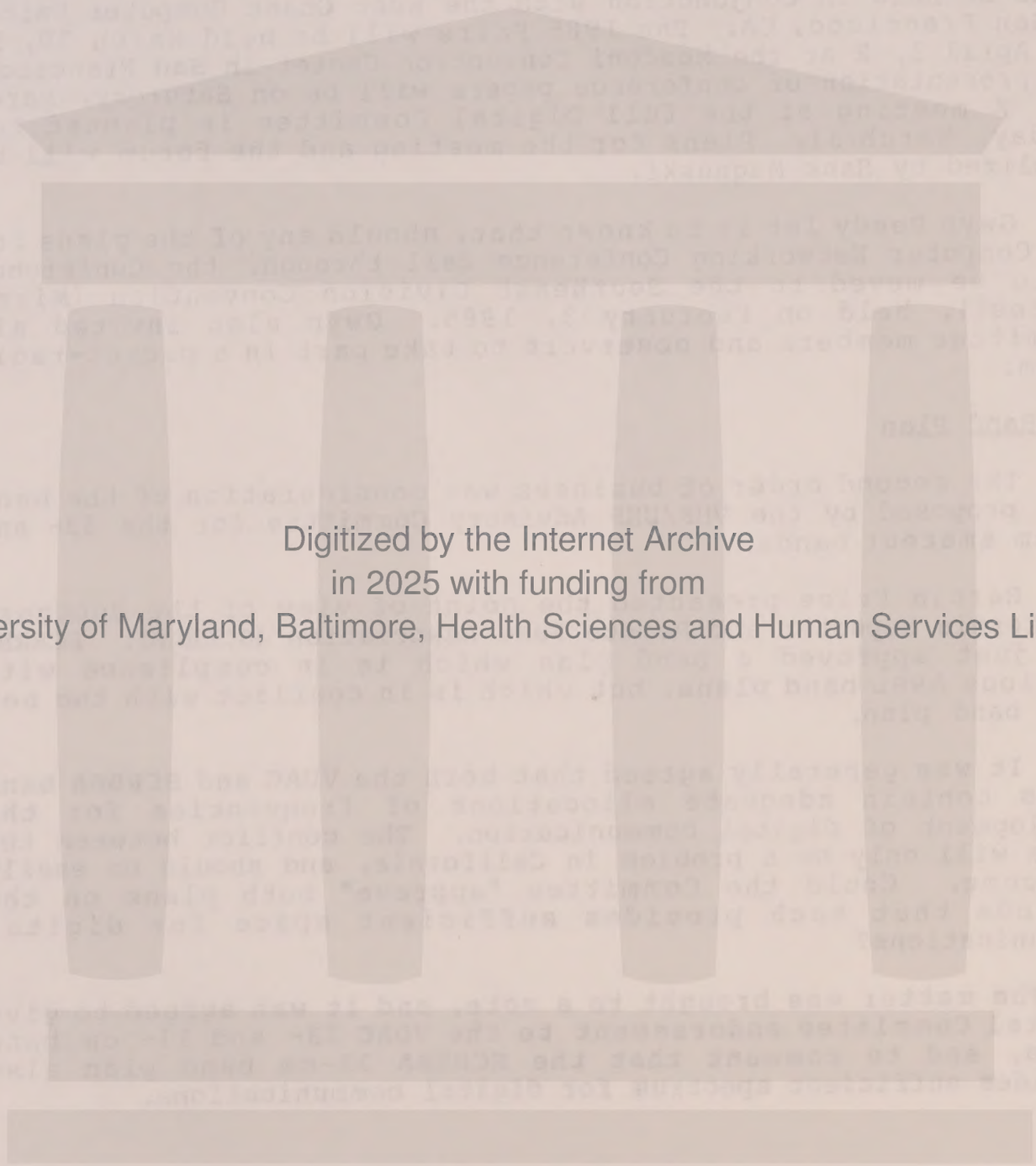
UHF Band Plan

The second order of business was consideration of the band plan proposed by the VHF/UHF Advisory Committee for the 33- and 23-cm amateur bands.

Harold Price presented the point of view of the Southern California Repeater and Remote Base Association (SCRRBA). SCRRBA has just approved a band plan which is in compliance with previous ARRL band plans, but which is in conflict with the new VUAC band plan.

It was generally agreed that both the VUAC and SCRBBA band plans contain adequate allocations of frequencies for the development of digital communication. The conflict between the plans will only be a problem in California, and should be easily overcome. Could the Committee "approve" both plans on the grounds that each provides sufficient space for digital communications?

The matter was brought to a vote, and it was agreed to give Digital Committee endorsement to the VUAC 23- and 33- cm band plans, and to comment that the SCRRBA 23-cm band plan also provides sufficient spectrum for digital communications.



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Level 2 Protocol Discussion

The purpose of this discussion was to decide what protocol was to be sent to the ARRL Board of Directors for approval, and what was to be gained from the Board approval. Points of discussion:

- Who will maintain the standard, and how?
- The Committee will maintain the standard, but has no fixed procedure for such maintenance.
- Board approval will have the effect of making this an internationally recognized standard.

In order to better choose a course of action the Committee allowed Terry Fox to discuss AX.25, and Doug Lockhart to discuss the shortcomings he finds in AX.25.

Terry's points:

- AX.25 uses amateur call signs for addresses, so no central administration is necessary, and each packet carries a legal ID.
- Digipeaters as in AX.25 have strengthened the growth of packet radio.
- The protocol is mature, has been implemented on several TNCs by many groups, and has been modified where modification was necessary.

Doug's points:

- The AX.25 document states that AX.25 is "similar to" X.25, in Doug's opinion, it is not.
- "Temporary" facilities, such as digipeaters should not be in the document.
- The Protocol Identifier (PID) field belongs in a Level-3 specification.
- No provision is made for "in-frame" identification of protocol version.

After an extensive discussion, it was VOTED to purge from the body of the AX.25 protocol specification all comparisons to X.25. These references will be put in the preface.

It was VOTED to leave digipeaters in the AX.25 document.

After some discussion of what were "editorial matters," it was VOTED to refer editing details to a subcommittee for finalizing the document.

After lunch, the committee discussed Doug Lockhart's V-2 protocol. This was a drawn-out discussion. The Committee was not willing to say that no further level-2 protocols would be approved. There may be a need for forward error correction, meteor-scatter, or other specialized level-2 protocols. However, everyone agreed that it would be unfair to encourage work on a protocol that was not likely to approved by the committee.

Vice Director Quiat expressed his opinion that the marketplace has already decided that the "standard" level-2 protocol will be AX.25. V-2 is not compatible with AX.25. The growing packet-radio user base deserves a unified approach to level-2 protocols. Marshall finished by saying that the Digital Committee should welcome Doug's help with the remaining protocols, but move forward, unified on level-2 standards.

There was a motion to refer the V-2 protocol to a subcommittee for further study and documentation. The motion died for lack of a second.

Network Protocol Discussions

Paul Rinaldo opened the discussion of Amateur packet-radio networking, saying that the development of a level-3 protocol is a major hurdle that the amateur-packet community must overcome. The users have been promised a network, and now the experimenters and the organizers have to design and implement one. Paul went on to state that the immediate objective of the Digital Committee should be to guide networking experiments, and to show the users that a the development of a packet network is underway. He stressed that the Committee was not going to sit in the conference room, write a standard, and "force it down the people's throats."

Wally Linstruth suggested that we introduce some structure to our discussion. Packet networks are traditionally designed from the top down, so that the final network will have the desired characteristics. Amateur packet radio exists in a "dynamic anarchy;" each local network is not the result of some engineer's design, but the result of the individual actions. The Digital Committee has the opportunity to give some structure to the design of the amateur packet-radio network. Toward this end, the Committee developed a problem statement and a requirement specification for amateur packet radio networking.

The problem was simply stated by Terry Fox, "I want to be able to send data to and receive data from any packet station in the world."

The requirement specification was developed during a brainstorming session. Major points made during this session follow:

- o A user should need only a TNC to access the network.
- o The network should be easy to operate.
- o The network should support a wide variety of media (HF, VHF, satellite, microwaves, meteor scatter, etc.).
- o The network should remain amateur in spirit.
- o The network should not be highly centralized
- o The network should work when commercial networks are down; in the event of emergency, the network should still be available.
- o Network users should be able to specify their needs (for example, a choice of speed over reliability).
- o The network should be able to resist jammers.
- o The network should be able to take advantage of new stations when they come on the air, and should not be crippled by stations leaving the air.
- o The network should support traditional amateur operating modes, rather than forcing amateurs to change their habits.
- o Both real-time and store-and-forward operation should be supported.
- o Controlled broadcast, or alert should be available.
- o Round-table operation should be supported.
- o There should be a network directory available on the air.
- o Fault detection and isolation should be easy.
- o The network should function well in various geographical regions.
- * There should be a mechanism for monitoring the performance of the network.
- o There should be no user "passwords" or other "authentication."
- * The network should be data transparent; whatever data is sent from the source should be received unchanged by the destination.

- The network should be global.
- The goals set for the network should be attainable within the limited, amateur resources available.
- It should be possible to positively identify nodes.
- Network hardware and software should be modular.
- Seek funding from outside foundations (i.e., ARRL Foundation, NSF).
- Able to function in the amateur anarchy.
- Connections should be "traceable."
- Should be interoperable with other networks.
- The network should be able to exersize some control over users (i.e., routing connections around congestion, limiting traffic).
- The network should be able to accommodate connections with large volume of traffic flowing in only one direction, with large volume in both directions and with small volume in both directions.
- We must not underestimate the cost of creating the network.
- We must keep the cost of end-user nodes down.

The Committee then identified goals that should be met by the first protocol implementations. Those goals are marked by asterisks in the above list.

These goals might be met more easily if, in the first implementation, network protocol resided in a server node. Then, users with only level-2 TNCs would access the network by connecting to the server node. The protocol used between the TNC and the network server is called the "access-link protocol." Harold Price revealed that he and the TAPR software team would be working on a standard access-link protocol. The access-link protocol allows the user to 1) start a call, 2) transfer data, and 3) end the call. It should also support flow control and error reporting. Such a protocol will be used no matter what network protocol is eventually agreed upon.

Terry Fox and Eric Scace gave tutorials on virtual-circuit (VC) protocols, concentrating on the CCITT X.25 level-3 protocol that Terry has recommended for amateur packet radio. These tutorials were comprehensive, and cannot be reproduced here. Here are a few highlights of the discussion:

- VC networks deliver packets in sequence.
- Congestion and link failure can be recovered from, but data may be lost.
- Use of a level-4 protocol on top of VC network can assure end-to-end data integrity.
- The increase in throughput realized by using VC protocols (instead of datagrams) is not because of decreased packet overhead, but because VC nodes do not make routing decisions for each packet that they handle.

Phil Karn described the Defense Advanced Research Projects Agency (DARPA) Internet Protocol (IP). IP is a datagram (DG) protocol, and several experimenters are recommending it for amateur packet radio use. Phil's major points:

- IP is a standard for many types of networks.
- You do not necessarily need Transport Control Protocol (TCP) above IP.
- A DG protocol can easily route around congested areas of the network.
- IP was designed to work in an environment where nodes come and go frequently. The amateur packet network will likely be such an environment.

These tutorials, and following question-and-answer sessions occipied the the committee until the end of Saturday's meeting.

Sunday, September 16

ARRL Contributions to Packet Radio

Sunday's meeting began with some general discussion of what the ARRL is doing and could do to advance packet radio. The ARRL has OST, QEX, and Gateway in which to publish articles concerning packet radio. There may be a series of TNC reviews, club profiles, and technical articles. Whereas we do not pay authors, OST has a larger circulation than all other ham magazines combined. The ARRL is also looking at how packet radio fits into the field organization, NTS and ARES.

Network Experiments

There was still no clear agreement among Committee members as to whether X.25 or TCP/IP was the better choice for amateur packet networking. Therefore, the Committee decided to support experimentation with both of the protocols.

In order for the experiment to identify a successful protocol for amateur use, resulting IP and X.25 implementations must perform the same tasks in the same environment.

There was general agreement that the test environment should be Xerox 820 computers modified to run at 4 MHz. Each Xerox 820 should support one 8530 HDLC chip. Lyle Johnson said that TAPR agreed to put together a kit of parts to add these modifications the the Xerox 820. In order for the implementations resulting from the experimentation to be developed on and portable to environments other than the Xerox 820, programs should be developed in a transportable, high-level language. The "C" language was chosen. All programs are to be compiled using the Aztec C compilers from Manx Software.

Network protocol implementations based on the above experimental environment should be modular and portable.

Network Implementation

The remainder of the Committee meeting was spent discussing the details of the first network implementations. What should be supported? What common set of terms should we agree on? Should there be some level-4 (transport layer) functions be included in the first implementations? The more interesting, clear-cut opinions expressed follow:

Transport Layer vs. Network Layer

A network/transport-layer protocol implementation must provide the following services:

1) Connection establishment
2) End-to-end acknowledgement of data
3) Recovery from data/connection loss
4) Routing
5) Flow control

X.25, a network-layer protocol, handles 1, 2, 4 and 5. X.25 networks need a transport layer to handle 3.

IP, a network-layer protocol, handles 4. In IP datagram networks, 1, 2, 3, and 5 must be handled by a transport-layer protocol.

Whichever network-layer protocol we adopt, we are going to need some transport protocol to ensure data integrity.

Functions and Terms

Rather than giving a name to each type of network node and TNC, we should refer to the functions performed by the node:

ME Medium (physical) endpoint
LE Link endpoing
LX Link transit (digipeat)
NE Network-layer endpoint
NX Network-layer transit
TE Transport-layer endpoint
CC Call control

For example, a node that reassembles datagrams provides NE service; to make a call, the user interacts with a node providing CC.

Several functions may be provided by one piece of equipment.

Network Phase-0 Requirements

Committee members were not entirely sure what would be implemented in the Phase 0 of network software/hardware. It was agreed that the first network controllers should:

1) provide end-to-end acknowledgement
2) rely only on explicit, user provided routing
3) simultaneously handle calls for several users (exact number?)
4) report call failures.

More proposals and specifications will be forthcoming.

Action Items Identified

1)Finishlevel-2 statetables and diagrams.
2) Identify and develop Xerox 820 modifications.
3) Develop network access protocol.
4) Implement experimental virtual-circuit protocol.
5) Implement experimental datagram protocol.
6) Identify protocol testing procedures and criterion.

Actions Taken

1) Endorsedthe digital spectrum space allocations made in VUAC and SCRRBA bandplans as adequate for the growth of digital communications.

2) Approved AX.25 level-two document for submission to the Board in October, 1984.

3) Identified network-layer objectives.

4) Agreed to use the Digital Committee as a clearinghouse for network-layer experiment information.

5) Agreed to meet next in Los Angeles on November 11, 1984.

6) Agreed to hold the Fourth ARRL Amateur Radio Computer Networking Conference at the Tenth West Coast Computer Faire (March 30, 31, April 1, 2, 1985). The Conference will be on Saturday, and the Digital Committee meeting on Sunday.

THE AMERICAN RADIO RELAY LEAGUE, INC.
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ADMINISTRATIVE HEADQUARTERS NEWINGTON, CONNECTICUT, U. S. A. 06111

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September 5, 1984

Mr. Doug Lockhart, VE7APU
9531 Odlin Road
Richmond, BC
CANADA V6X 1E1

Dear Doug:

Thanks for all your papers. I've photocopied them and mailed them to the other digital committee members.

Congratulations on your being awarded the CRRL Certificate of Merit for your packet-radio work at the August CRRL Board meeting.

73,

Paul L. Rinaldo, W4RI
Manager, Technical Department

PLR/msa

1984 AUG 27 01:11:24

9531 Odlin Road,
Richmond, B.C. V6X 1E1
August 20, 1984

Paul Rinaldo, W4RI
Manager, Technical Dept.
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225 Main Street
Newington, CT 06111

Dear Paul,

Under separate cover I have sent you my comments on the X.3 and X.28 protocols. Thanks very much for sending me the documentation regarding these protocols.

Over the summer I have been busy implementing the V-2 protocol as per the specification document that was published as a result of the Trenton conference. This has been my major concern with regard to packet radio activity. I am pleased to report that with the second test implementation it appears to be working satisfactorily and only a very few minor bugs have been reported - the major complaint was that the interface to the terminal was too restrictive which really has nothing to do with the V-2 protocol. So anyway, I am now working on adding some requested user facilities to the TIP part of the software. That should be ready fairly shortly and the package should be complete. I am also adding the functions as per X.3 and X.28. The only part of the specification not in the code is the full-duplex support but that will come shortly.

Also of note, the V-2 protocol has been successfully implemented on an IBM PC independently using the specification document as a guide. Surprise - when we tried to communicate between the IBM PC and a VADCG TNC running V-2 it worked first time! I guess I did a good job on the document after all. The IBM PC uses a special prototype board with an 8273 on it to communicate with.

Because of my concern with the above I have not provided you with my ideas for level 3 which is the main topic of the meeting in September. I will write you in the next few days with some ideas and bring some more with me to the meeting.

Although I have my own ideas on the P/F bit in AX-25 I have not gotten involved in the heated discussion on this issue by choice. Any comments I make regarding AX-25 are always construed to be an attack on a sacred cow by some AX-25 supporters. In any case, it is not a matter of direct concern to me since I am working with a different protocol which does not have this problem and it is not a major issue even with AX-25. The important issue re AX-25 is the question of how it should be changed to add level 3 functions to it.

I have made airline reservations and have been able to get a cheap ticket but I won't be able to make any changes after the 30th of August or else they will charge a lot more. The round trip to Hartford is only about $428 U.S. I will be arriving in Hartford on Piedmont flight #88 at 7:10 P.M. on Thursday, September 13. My return flight on Piedmont #77 leaves Hartford on Monday, the 17th of September at 6:45 A.M. Please make hotel reservations for me and tell me what to do upon arrival at the airport.

I hope the meeting proves to be productive. I remember that some people at Trenton did not want to have this meeting. I also hope that the meeting does not turn into an AX-25 meeting only. I am going to be in the minority in any case as I believe all the others are AX-25 proponents.

73

Doug

Douglas Lockhart, VE7APU

27

9531 Odlin Road,
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August 20, 1984

Paul Rinaldo, W4RI
Manager, Technical Dept.
American Radio Relay League
225 Main Street
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Dear Paul,

Many thanks for sending me the information on "Packet Assembly/Disassembly (PAD) CCITT Recommendations X.3, X.28 and X.29. The document arrived at just the right time for me because I had just completed most of the major work on the implementation of the V-2 protocol on the VADCG board and was just beginning to work on adding improvements to the TIP (Terminal Interface Program). So you see, they arrived at just the right time for consideration.

Although you didn't mention it in your letter I assume you are tacitly suggesting that these recommendations be implemented to standardize the terminal user interface to the various TNCs that are available. If so, then I think we are in agreement. I have already implemented some of these recommendations in the V-2 implementation I am working with here as a result of receiving the information from you.

Although most of the functions in recommendation X.3 are already available in the VADCG and TAPR boards (as well as others), there is no standard way for the user to interface with the keyboard to perform the functions or change the options. The VADCG software currently uses a large set of 2 character commands to control the TNC. For example 'EC' to enable echo and 'NE' to disable echo. The TAPR TNC uses a different large set of variable length commands to control the TNC such as 'E ON' to enable echo and 'E O' to disable echo.

With the self-imposed idea of making all commands only 2 letters long, it has become difficult to choose letters that make sense to the user and it becomes necessary for the user to memorize a large set of almost meaningless 2-character codes or to frequently consult a list to find the right mnemonics. The TAPR mnemonics being variable length add an additional complexity to this problem. The AX-25 implementation for the VADCG board uses yet another system of terminal command mnemonics as does the PK-1 board and the original Vancouver protocol implementations.

All these different ways of doing the same thing can be very confusing to the terminal operator shifting from one system to another. What we need is a standard way of controlling the TNCs from a keyboard and X.3 and X.28 seem to offer much of this.

I propose that we implement support of the X.28 command signals in Table 2 on page 10 and the 22 X.3 parameter values in Appendix A on all TNCs. As mentioned, I am in the process of doing it for the V-2 implementation for the VADCG TNC.

There are some problems with implementing the X.3 and X.28 recommendations on current TNCs as follows.

1. Not all TNCs support all the functions defined in X.3. This should not be much of a problem as it is only necessary to return an invalid parameter message when an attempt is made to use a non-implemented function. An effort should be made to implement as many of the functions as possible however.

2. Functions not defined in X.3 and X.28 are available and necessary on TNCs. I recommend that these functions be implemented on parameters 23 and up which are not at present being used by X.3.

3. The new functions mentioned in 2. above may be implemented in different parameters by independent groups. To prevent this, an effort should be made at standardizing the implementation of the function. i.e. the same parameter number should be used if possible. The ARRL Digital Committee facilities could be used to assist with communication to further this end.

4. It will not be practical to implement all new functions using the terminal commands listed in X.28 Table 2. New terminal commands may be required for these new functions. For example, it is probably not practical to implement a "DUMP" function using the 'SET' command so a 'DUMP' command will have to be added to the list. The recommendations in 3. above apply to this as well.

5. Some signals have not been standardized in X.28 such as the command prompt, incoming call message and the terminal command to set up a virtual call (connection). The current command prompt in the latest V-2 software is '--> ' whereas the prompt in the TAPR software is 'cmd:'. Again, efforts at standardization should be made as in 3. above.

6. As mentioned on page 16 of the document, some of the messages specified in X.28 are not 'human engineered' and are generally not implemented as defined. An agreement on the format of these messages for the Amateur Radio environment should be obtained. As an example, the message "CLR PAD" might better be implemented as "<Call sign> DISCONNECTED" in the Amateur Radio environment.

I believe that the issues dealt with in the X.3 and X.28 recommendations concern level (layer) 6, the Presentation layer of the ISO Reference Model for Open Systems Interconnection (OSI).

If we get the chance, this may be a suitable topic of discussion at the September meeting although many of those present may not be properly prepared to discuss it. I should have most of the X.3 and X.28 recommendations operational on the VADCG TNC by the time of the meeting.

73,

Doug

Douglas Lockhart, VE7APU

9531 Odlin Road,
Richmond, B.C.
Canada V6X 1E1
August 26, 1984

Paul Rinaldo, W4RI
Manager, Technical Dept.
American Radio Relay League
225 Main Street
Newington, CT 06111

Dear Paul,

I see from your letter of August 15 to the Committee that you are in the process of submitting level 2 protocols to the ARRL Board of Directors for their 'approval'. I am enclosing a copy of the V-2 level 2 specification document so that it may also be approved by the board. Also enclosed is an 8-inch CP/M diskette containing the document in machine readable form so that you may give it any cosmetic editing you feel it needs before submission. It is in WordStar format which I know you can handle. Please distribute the document to the Committee members.

At the present time V-2 is in use in a number of areas in the U.S., Canada and Australia and is working very well. Implementations are operational on the VADCG TNC and on the IBM PC using a special interface board plugged into the PC. An implementation for the Ashby TNC will be available shortly. The implementations for the different systems were made using the specification document as a guide and in the process we did not run into any of the incompatibility problems that were experienced with the early AX.25 implementations. This can be taken as proof of the adequacy of the original specification document.

Unlike AX.25, which is still undergoing debugging and changes such as the P/F bit problem and the retransmission of I-frames on error recovery, etc., V-2 does not have these problems or bugs. V-2 does not have the problem of incompatible versions which still exist in various AX.25 systems at the present time.

Frankly, I do not see how it will be possible for the Board of Directors to approve AX.25 as a level 2 protocol since AX.25 is **not** a level 2 protocol in the first place. AX.25 does not provide even the basic functions to make it a link level protocol as defined by the ISO model. AX.25 has no link level error recovery, no retransmissions, no acknowledgments, or sequence checking on links. It also does not provide for parameter exchange with peer data link parties. In fact, AX.25 has very few link level functions and mainly concerns itself with level 3 (Network) and 4 (Transport) functions such as routing, end to end flow control, end to end error recovery and end-to-end connection establishment and release.

The above point has been made a number of times by myself and others but appears to have gone unnoticed (ignored?). Chapter 15 of the V-2 specifications makes this point and, more recently, it was made by Phil Karn when he wrote, "... what we call our Link Level Protocol is actually an end-to-end stream protocol analogous to TCP."

Many people give lip service to the ISO model and I believe it has a great many good ideas. I know that you have expressed your approval of the concepts in the ISO model. AX.25 is a mishmash of the Datalink, Network and Transport levels of the ISO model and so I cannot support it as a standard and I cannot understand why anyone who really understands and approves the ISO model could support AX.25 as some kind of a standard.

V-2, on the other hand, is a true level 2 protocol as per the ISO model and contains all the features described by the ISO model.

Another concept which has almost universal support by professional communication prototcol designers is the 'shell' or 'layer' concept. This is the system where the various protocol layers are each contained in separate headers at the beginning of a frame or block. Each header contains all the information to support the layer concerned and only the information for that layer. The headers are arranged in the same sequence as the layers that the frame will pass through allowing the headers to be successively stripped off as the block passes to higher levels for processing. Unfortunately, AX.25 does not comply with this concept either. For example, the same fields in the AX.25 header are used both for link addresses and for routing addresses. V-2, however, does comply with this concept.

At the September committee meeting we will be discussing level 3, the Network layer. If, as I see suggested, the level 3 is placed above the AX.25 protocol, we will be faced with a system which has two sets of routing functions, one in the new level 3 and the other in AX.25. The level three will have to pass a set of call signs to AX.25 to tell it a route and then have to figure out a route of its own to put in its own level 3 header. This would force the new level 3 to involve itself with a routing system based on call signs. Besides being awkward and in non-compliance with the ISO model it also means AX.25 will be dictating to the new level 3 layer the type of routing system it must use. A lower level protocol level should never impose such requirements on a higher level protocol. Although V-2 uses a linking system based on call signs, it does not require a routing system based on call signs. The V-2 level 3 protocols are free to use whatever routing system wished and V-2 has the facility to select different level 3 protocols. V-2 level 3 experimentation will likely be done using a number of different systems. One of which could be the call sign routing system used in AX.25.

There seems to be an assumption which runs through many of the documents on AX.25 that by the use or modification of an existing protocol, namely X.25, we would be able to benefit from the work done by the developers of X.25 and not encounter any problems. This assumption runs contrary to actual fact and to the opinions of the most qualified experts on protocols. To quote Kleinrock, "In our experiments ... we have occasionally attempted to adopt a protocol from one network directly over into a new network. We have found that this is a dangerous procedure and must be carefully analysed and measured before one adopts such a procedure. Indeed, the use of old protocols in a new environment is dangerous."

In particular, trying to use a full-duplex, point-to-point, master/slave type protocol like X.25 in an Amateur radio environment needing a half-duplex, multipoint, peer-to-peer type protocol is particularly dangerous. Most of the problems in AX.25 have been encountered because of the inherent unsuitability of X.25 to the Amateur radio environment. The only reason AX.25 gets off the ground is because it is radically different from X.25. Why this unsuitable protocol was ever chosen as a model for the Amateur environment in the first place is hard to understand. Why was not a half-duplex, multipoint, peer-to-peer protocol chosen as a model in the first place? It would have been much closer to what we need. X.25 was intended as an interface protocol to the public packet switched networks, not as the protocol used in those networks themselves.

Another idea which permeates the AX.25 literature is the belief that we will be able to interface to the existing public packet switched network by using X.25 as a model. In actual fact, the major differences between X.25 and AX.25 at the link level make it necessary to have a gateway to perform this function. Will it be easier to write this gateway function because of the use of AX.25 link level as opposed to some other protocol? The answer is no. The gateway function is easier to write for V-2 link level because of its simpler and fixed length addressing structure.

I am concerned not only with doing the job but with doing the job right. I believe that V-2 link level is a better protocol than AX.25 for many reasons of which only a few I have mentioned above. I hope that the choice of an Amateur radio protocol does not turn into a numbers game.

If you need it for the Board, I can supply you with a state diagram for V-2 which is not included on the diskette. Please contact me if you need it.

73, Doug

Douglas Lockhart, VE7APU

V-2

A NEW VANCOUVER PROTOCOL

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Abstract

This paper describes a datalink protocol developed by the author in Vancouver. It is designed to replace the previous link level protocol commonly known as the 'Vancouver protocol' and it addresses all the major limitations of that protocol.

August, 1984

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PREFACE TO AUGUST, 1984 EDITION

This edition of the V-2 protocol document is essentially the same in content as the March, 1984 edition published in the Third ARRL Amateur Radio Computer Networking Conference. The format has been changed and a few typographical errors have been corrected. The only text changes have been made in Chapter 10 concerning the handling of the Ready and Not ready conditions. The requirement of sending two RR or two RNR frames under certain conditions has been removed, simplifying the protocol and making the specification fit the existing implementations. This change does not substantially effect the operation of the protocol nor result in any incompatibility with any implementations designed using the previous specification.

Since the March publication of this document, the protocol has been implemented on the VADCG TNC and on the IBM PC using a special board containing an Intel 8273 chip. Both implementations were made using this specification as a guide and when tested together, the two systems communicated successfully.

Testing of the protocol and its implementations have been made by several groups at different sites. These tests indicate that the protocol works as expected with no surprises. Some timing comparisons have been done which indicate that this protocol is approximately 20% faster than AX-25 when transferring files.

A meeting of U.S. (only) packet radio groups was held in October, 1982 which resulted in the adoption of a protocol commonly known as 'AX-25' by most U.S. packet radio groups. (I would have liked an invitation.) AX-25 addresses most of the limitations of the Vancouver protocol but is not a true link level protocol since it concerns itself with several network level functions as well. It is also undergoing changes at the present time and has its own set of problems and limitations. It is my preference to have a protocol which makes a clear separation of link level and network level functions as per the ISO model. As far as standardisation is concerned, when signals with other protocols arrive in the area we hope to be able to provide a gateway interface to handle them.

For purposes of discussion I will refer to the orginal Vancouver protocol as the 'Vancouver protocol' and the new protocol as 'Vancouver Version 2 protocol' or 'V-2' for short.

INTRODUCTION TO V-2

The V-2 protocol is intended to be an efficient datalink level protocol specifically for the Amateur Radio environment but potentially usable in other environments as well. Both full and half-duplex modes are defined. After link establishment, V-2 has only 5 octets of overhead per frame in addition to the standard 3 or 4 octets required for framing. It is strictly a datalink protocol and does not provide any network level functions. The network level protocol will be provided in a Network header which appears only in Information-transfer frames.

All control information for the link and only control information for the link is carried in a Link Header and Link Trailer which appear at the beginning and end of every frame respectively. Only the information not in the link control fields need be passed to higher levels of protocol. This separation of both function and headers allows software for layers to be developed in modular form and permits modification of the code for one layer to have minimal affect on other layers.

This protocol makes no claim or intent at comparison or simulation of the CCITT X-25 standard although it is the author's opinion that V-2 can be compared in the same way as AX-25 can to X-25 with as much similarity or more.

Frame Structure

All transmissions are sent in frames similar to IBM's SDLC and the CCITT's HDLC as well as to AX-25 and the older Vancouver protocol. The frames are encoded in (and decoded from) NRZI (Non Return to Zero Inverted) mode by the HDLC protocol controller chip. The general field format of a V-2 frame is as follows:



Field Descriptions

Sync field

This field is used for preframe synchronisation. It is either 16 bits of zeroes or sufficient flags for the receiving side to establish bit synchronisation. This field is basically under control of the HDLC protocol controller chip and is transparent to the software.

Flag fields

All frames begin and end with a flag which is the bit sequence 01111110. When sending multiple frames one after the other, the trailing flag of one frame may be used as the leading flag of the next frame. The HDLC protocol controller chip uses a bit stuffing and deleting technique to ensure that a flag sequence can only appear at the beginning and end of a frame. Flags are automatically inserted by the HDLC protocol controller chip on transmit and are likewise automatically deleted from the data stream before passing to the software. i.e. the flags are transparent to the software.

Address field

This is a four byte address used to identify the link. The old protocol used a one byte address. How it is formed is discussed later. This field is generated and checked by software.

Control field

This is a one byte field. It is used to identify the type of frame and provides information for supervision of the flow of data over the link. This field is generated and processed by software. The format of this byte is discussed later.

Information field

This variable length field is only present in certain

types of frames. It must be an integral number of octets. Although the hardware allows a maximum length of over 65,000 bytes, it is recommended that a maximum length of only 200 bytes or less should ever be created for transmission. On the other hand, the system should be capable of handling frames of longer lengths say up to 250 bytes when received from other nodes. This allows room for higher level overhead should it be necessary. If unusually long frames are to be sent, higher level protocols should agree on the size in advance.

FCS (Frame Check Sequence)

This is a two byte field generated as per ISO standard 3309. This field is automatically generated, checked and removed by the HDLC protocol controller chip so I will not discuss it further. It is used to verify the accuracy of the rest of the data in the frame.

Frame Types

There are three types of frame formats: unnumbered, supervisory, or information transfer format. The frame type is indicated by the value of the low order bit or bits in the control field as seen in storage. (Note that this article refers to the fields as they are seen in storage - not as how they are transmitted by the protocol controller chip) If the low order bit (bit 0) is 0 then it is an information transfer frame. If both bit 0 and bit 1 are 1 then it is an unnumbered frame. Finally, if bit 0 is 1 and bit 1 is 0 then it is a supervisory frame.

Unnumbered-format frames (U-frames) are used during link establishment and termination. They are also used to transfer data when the data is not to be checked as to its location in a sequence of frames. There are a possible 32 types of U-frames but only three of these are used in this protocol.

Supervisory-format frames (S-frames) are used to assist in the transfer of information in that they are used to confirm preceding frames carrying information. The frames of the supervisory format do not carry information themselves. These frames carry an Nr count which is used to confirm received frames. They also convey ready or busy conditions which assist in coordinating flow control across the link and they are also used to report frame numbering errors (indicating that a numbered information frame was received out of its proper sequence). There are a possibility of 4 types of S-frames but only 3 are defined in this protocol.

Information-transfer format frames (I-frames) actually transfer the data from higher protocol levels across the link. The control field contains send and receive counts

(Ns and Nr), which are used to ensure that these frames are received in their proper order (Ns) and to confirm accepted information frames (Nr). The Ns count indicates the number of the information frame within the sequence of information frames transmitted. The Nr count transmitted in a frame is the number (Ns) of the information frame that the node transmitting the Nr expects to receive next.

Frame numbering

A node transmitting numbered I-frames counts each such frame and sends the count with the frame. This count is a sequence number known as Ns. This sequence number is checked by the receiver's datalink layer for missing or duplicated frames.

A node receiving I-frames accepts each numbered frame that it receives (that is error-free and in-sequence) and advances its receive count for each such frame. The receiver count is called Nr. If the received frame is error-free, a receiving station's Nr count is the same as the Ns count that it will receive in the next numbered information frame; that is, a count of one greater than the Ns count of the last frame received. The receiver confirms accepted numbered I-frames by returning its Nr count to the transmitting node.

The Nr count at the receiving station advances when a frame is checked and found to be error-free and in sequence; Nr then becomes the count of the "next-expected" frame and should agree with the next incoming Ns count. If the incoming Ns does not agree with Nr, the frame is out of sequence and Nr does not advance. Out-of-sequence frames are not accepted. The receiver does, however, accept the incoming Nr count (for confirmation purposes) if the out-of-sequence frame is otherwise error free.

The counting capacity for Nr and Ns is 8, using the digits 0 through 7. These counts wrap around; that is, 7 is sequentially followed by 0. Up to seven unconfirmed, numbered information frames may be outstanding (transmitted but not confirmed) at the transmitter. All unconfirmed frames must be retained by the transmitter, because it may be necessary to retransmit some or all of them if transmission errors or buffering constraints occur. The reported Nr count is the number of the next frame that the receiver expects to receive, so if, at a checkpoint, it is not the same as the transmitter's next frame (Ns) number, some of the frames already sent must be retransmitted.

The Nr and Ns counts on both ends of the datalink are initialized to zero during the link establishment phase.

The Poll bit (P-bit) and receive timeout.

The Poll bit is bit 4 in the control field. It is used to force a response from the receiving node when set to 1 (on). Whenever a frame is transmitted with the P-bit on a receive timeout is started by the originating node. This receive timeout (T1) is in the order of 1-3 seconds. This timeout is cancelled by reception of any frame from the other side of the link. If the timeout expires before the expected frame is received then the transmitting node takes corrective action. The number of successive timeouts is counted and reset when a frame is successfully received. If the number of successive receive timeouts exceeds a predetermined level (N1), the next higher level of protocol is notified. The higher level may take other action such as terminating the link.

Note that the receive timeout only proceeds when the data link channel is clear. The timeout is suspended when the data link channel is occupied. On VHF, the datalink channel may be occupied by carriers, voice transmissions, QRM, etc. in addition to the expected data signals. For this reason, it is strongly recommended that CD (Carrier Detect) be tested for receive timeouts rather than DCD (Data Carrier Detect). All VADCG board installations that I know of in Canada are using the squelch line from the VHF transceiver rather than the Data Carrier Detect line from the modem. Some can select both. If the DCD line is used, excessive timeouts will occur and it will be difficult or impossible for the TNC program to determine proper action. In addition, the TNC will transmit on top of other stations using the channel which can lead to unpleasant verbal exchanges. Remember that no Amateur frequencies are exclusively reserved for this type of packet activity.

NODE NAMING AND ADDRESSING

Before describing link addressing it is necessary to understand the network node addressing and naming system in which this protocol is designed to operate. Also, some terms need to be defined.

Node - In this article the word, 'Node' refers to any entity in the communications system which originates or receives frames.

Node Names

Associated with each node in the network is a 7 character upper case string of ASCII characters. The first six characters of which are the Amateur Radio call sign padded by ASCII blanks (20 Hexadecimal) on the right. The final character is a suffix used to discriminate between multiple nodes which have the same call sign. This suffix will normally be an ASCII blank (20 hexadecimal) and any additional occurrences of the same call sign will be identified by the ASCII numbers 1,2,3, etc. Each node in the network thus has a unique call sign.

For example:
KA6M*** (The * represents a blank)

Or if KA6M has another node operating:
KA6M**1

Node Address

Also associated with every node in the network is a two byte (16-bit) binary address. This address can be derived from the node name by use of a modified cyclic redundancy (CRC) checking algorithm. The algorithm operates on the 7-byte (56 bit) node name handled as a polynomial of degree 56 and generates a two byte (16-bit) number.

The algorithm does not generate node addresses with FF (hexadecimal) in the first byte because these are reserved for special broadcast functions. Please see Appendix A for details of the algorithm and a sample implementation for an Intel 8080 microprocessor.

The special destination node address of FFFF (Hexadecimal) is used as a general broadcast address and destination addresses beginning with FF are reserved for selective broadcasts and special purposes.

Link Address

The link address field in the frame is four bytes long and is generated by concatenating the 2-byte node addresses of the nodes at either end of the link. Each link actually has two addresses, identifying the two directions that data can flow accross the link. For example, if A and B represent the node addresses of linked nodes then AB and BA are the two addresses of the link between the pair. Address AB represents the link address for data originated by B and destined for A while BA represents the link address for data originated by A and destined for B. The destination node address always comes first.

Use of Selective Receive

This link protocol has been designed to make good use of the selective receive function available on most HDLC/SDLC protocol controllers such as the Intel 8273. The 8273 can be set to pass to the software only frames which have a specific combination of bits in the first byte after the leading flag. In this protocol, this byte is the first byte of the destination node's address. If a node does selective receive only on the first byte of its address, it can eliminate 99.6% (on average) of the link traffic from having to be read into memory buffers and analyzed by software and yet still be able to do multiple link establishments, terminations, etc.

There are a number of modes of operation possible with this protocol using selective receive options as follows:

1. Selective receive only on the first byte of the node's address for using multiple links as above. This would normally be used in anything but the unlinked state but would be used in the unlinked state if it was not desired to do any of the activities in items 2 and 4 below such as a node with a CBBS host.

2. Selective receive only on address FF (Hexadecimal) to monitor broadcast type transmissions and not establish links.

3. Selective receive on address FF and also the first byte of the node's address. (2 selective receive addresses are supported on the 8273) Links can be set up and broadcast messages can be received. Useful in the unlinked state.

4. Receive on all addresses. This is not a selective receive but it is useful for evesdropping on transmissions intended for others or monitoring activity on the channel to put it more politely.

Link States

Data links are set up and discontinued as required by the nodes in the network. They are temporary. The normal life history of a datalink usually progresses through three basic phases or states namely: establishment, information transfer and termination. Although technically not a link state, the situation where a node has no datalinks in any of the above phases is called the 'unlinked' state.

INFORMATION-TRANSFER FRAMES

I (Information) frames are numbered. The Ns count provides for numbering the frame being sent and the Nr provides acknowledgement for the I frames received. When duplex information exchange is in continual process, each node reports its current Ns and/or Nr counts in each I or S frame exchanged. I-frames are only originated by nodes that are in the information-transfer phase.

The expected acknowledgement is an S or I format frame whose Nr count confirms correctly received frames. (S-frames may be interspersed with I format frames, as needed.) An I-frame always has an I-field, in fact, an I-format frame is considered invalid if it does not contain an I-field in this protocol. See figure 1 for the layout of the I-frame control field.

Control Field Type	Control Field Bits 7 6 5 4 3 2 1 0
I-frame	Nr P Ns 0

Where:
Ns is the send sequence number.
Nr is the receive sequence number.
P is the Poll bit.

Figure 1. I-Frame Control field

I-Field Content

The contents of the I-field in an I-frame are not the concern of the datalink protocol. They are determined by higher levels of protocol. The design of the V-2 network level has not been completed and will be the subject of another paper. However, the work on the network level has progressed sufficiently that some advice can be given to network level implementors and testers that will allow different network headers to be identified and to co-exist on the same channel. It is for this purpose that the following Network level information is included here.

The first sub-field in the I-field is called the Network Header. It is a variable length field composed of an even number of bytes. The low order four bits of the first byte indicate the number of words (1 word = 2 bytes) long the the Network Header is. The high order bit indicates if there is another header following the Network Header and the three remaining bits are used to identify different types of Network Headers that may have the same length.

The bit layout of the first byte in the Network Header is as follows:

```
Bit number  7 6 5 4 3 2 1 0
            F T T T L L L L
```

Where: F indicates another header follows if 1
T T T indicates the Network Header type
L L L L indicates the length (in words) of the Network Header.

Even if only the link level protocol is in use the following two-byte dummy Network Header should be included as the first subfield in the I-field:

0100 (Hexadecimal)

This will indicate that the header is 2 bytes long and that no other header follows this one.

SUPERVISORY FRAMES

There are three types of supervisory frames defined by this protocol:

RR Receive Ready
RNR Receive Not Ready
REJ Reject

An S (Supervisory) frame must not contain an I-field. It is considered invalid if it does. See figure 2 for the layout of the control field of an S-frame. S-frames are only originated by nodes on links which are in the information-transfer phase.

Control Field Type	Control Field Bits 7 6 5 4 3 2 1 0
RR	Nr P 0 0 0 1
RNR	Nr P 0 1 0 1
REJ	Nr P 1 0 0 1

Figure 2. S-frame Control field.

RR (Receive Ready)

Indicates that the originating node is ready to receive I-frames and acknowledges receipt of numbered I-frames through Nr-1. It must be sent to clear a previous not ready condition (RNR). It can also be sent with the P-bit on to elicit a response from the node at the other end of the link. It is sent with the P-bit off in response to a poll by the other side when no I-frames can be sent.

RNR (Receive Not Ready)

Indicates that the originating node is temporarily not ready to receive I-frames and acknowledges receipt of numbered I-frames through Nr-1. It is usually sent when buffering limitations and other internal restraints in the node are encountered. It can be sent with the P-bit on to elicit a response from the node at the other end of the link. It is sent with the P-bit off in response to a poll by the other side when no I-frames can be sent. This not ready condition must be cleared by the sending of an RR or REJ frame. Note that the node should still be capable of handling S and U frames even in the not ready condition.

REJ (Reject)

Acknowledges receipt of numbered I-frames through Nr-1 and indicates that the originating node is ready to receive I-frames. It requests the retransmission of numbered I-frames starting at the Nr contained in the REJ frame. Its purpose is to speed up recovery of dropped frames when operating full duplex. Note that this frame is only used with full duplex links and should never be sent on half duplex channels. Only nodes intending to operate full duplex need incorporate support for this type of frame. It is optional. REJ frames may be interspersed in the sequence of transmitted frames on full duplex links. The REJ condition is cleared when the requested frame has been correctly received.

UNNUMBERED FRAMES

There are three types of unnumbered format frames supported by this protocol:

XID	Exchange station identification
DISC	Disconnect
UI	Unnumbered information (formerly NSI)

Unnumbered frames are not sequence-checked and do not use Nr or Ns. See figure 3 for the layout of the control field for these frames. Although I am using names and control field formats common to HDLC/SDLC nomenclature, the actual usage of the unnumbered frames in this protocol is different. I tried to use the HDLC name with the closest approximation to what this protocol is doing. I hope this does not cause any confusion. My other alternative was to use the undefined HDLC U-frames and give them my own names.

Note that the previously described I and S-frame usage adheres fairly closely to the HDLC/SDLC standards but there are major divergences in the usage of the unnumbered format frames. This protocol is not intended to be a copy of any other protocol but has been designed pragmatically. When a piece of another protocol fits the need, it has been used but when the need is unique, then unique solutions are designed. This method reduces the amount of development effort. It also helps those who are familiar with other protocols to quickly develop a familiarity with this one. On the other hand, there may be some confusion when divergences with the other protocols occur.

Control Field Type	Control Field Bits 7 6 5 4 3 2 1 0
XID	1 0 1 P 1 1 1 1
DISC	0 1 0 P 0 0 1 1
UI	0 0 0 P 0 0 1 1

Where:
P is the Poll bit.

Figure 3. U-Frame Control field.

XID (Exchange station Identification)

The XID frame is only used during the link establishment phase of the protocol. I was thinking of calling it the 'LINK' frame rather than XID. Before I-frames can flow across the link, information is exchanged between both nodes in the XID frames. The opposite node's XID information is analyzed and a determination is made whether or not the link can be established. If both nodes like what they see, then the link is established and I and

S-frames can flow across the link. On the other hand, if one node doesn't like what it sees, then it sends an XID frame to the other with a reason code filled in which indicates what it didn't like and the link is not established. XID frames are only transmitted on links in the establishment phase. The XID frame A, C and I fields are as follows:

AAAACSSSSSSSDDDDDDDPTR

Where:
AAAA is the address field.
C is the control field (XID).
SSSSSSS is the transmitting node's 7-byte name.
DDDDDDD is the destination node's 7-byte name.
P is the protocol level field.
T is the link type field.
R is the reason field.

Protocol level field (P-field)

This is a one byte field in the XID frame indicating the version of protocol being used by the originating node. By testing this field, the receiving node may determine if it can communicate with this type of protocol. At the present time, this field is 01 (Hexadecimal), indicating this is Level 0 of the protocol (bit 0 is on). This version number should be changed whenever a new level is produced which has features or changes which are not compatible with previous levels. This feature has been added in anticipation of future revisions and extensions of the protocol.

The receiving node checks for a match on this field. Note that a node may support multiple levels of protocol in order to communicate with nodes of different levels. For example, a primary station which supports multiple protocols may send an XID saying that it can communicate with levels 0 and 1 of this protocol by sending a P-field of 03 (Hexadecimal) with bits 0 and 1 on. The secondary determines if communication is possible by and'ing its own version(s) with that in the incoming P-field. If the result of this operation is non-zero, then the protocol levels are compatible and the secondary will respond with a P-field indicating which protocol it is using. If the result of this operation gives more than one bit on, then the secondary can choose which of the protocols it wishes to use.

For example:

1. Primary sends P-field of 03 indicating it can support levels 0 and 1.

2. Secondary logically 'ands' the primary's P-field with its

own protocol version number of Ø1 (Only supports level Ø). The result is Ø1.

3. Since the result was non-zero, the protocols are compatible and the Secondary can respond with a P-field value of Ø1. On the other hand, if the result is zero, then there is a protocol incompatibility and the secondary will respond with the protocol mismatch bit (another P-bit) set in the Reason field (R-field). The link will not be established.

Link type field (T-field)

The T-field is a one byte field in the XID frame indicating the type of link being established. At present the only choice in link type is either full duplex or half duplex. The byte format is as follows:

```
Bit number  7 6 5 4 3 2 1 Ø
            X X X X X X X F
```

Where X indicates reserved bits - must be Ø
F indicates full duplex if 1, half duplex if Ø

This field is checked by the receiving node and if it is capable of handling the type of link indicated it will respond with a matching indication in its own T-field. But if, for example, the primary requests a full duplex link and the secondary only has support for half-duplex, the secondary will respond with the Link type mismatch bit (T-bit) set in the reason field (R-field).

Reason field (R-field)

The reason field is a one-byte field in the XID frame used by the secondary to report to the primary the reason why the link is not being established. If any bits are on in this field, the link was not established. The R-field layout is as follows:

```
Bit number 7 6 5 4 3 2 1 Ø
           X X X X A R T P
```

Where:
X - reserved bit - must be Ø.
A - Address duplication (See Restrictions)
R - Resource limitation
T - Link type field mismatch (see T-field desc.)
P - Protocol mismatch (see P-field description.)

The R-bit being on (1) means that the originating node has a temporary resource shortage which prevents the establishment of the link. The most likely reason being that it has a limitation on the number of simultaneous links that the node can support. Most nodes used in Amateur Radio

so far can only support one link at a time, and so, if a node has this link already established when it receives an XID frame from a third party node, it should respond with the R-bit turned on.

Link Establishment

For purposes of the following discussion the node initiating the connection transmits first and is called the 'primary' node. The node being connected to is called the 'secondary' node. This distinction is made because the primary and secondary nodes use some of the fields in a slightly different way. This is a different use of these terms than is found in other protocol documents.

The following chart shows a normal link establishment between the primary node whose address is A and the secondary whose address is B.

```
BA,XID-P ---->                  Primary transmits XID
             <---- AB,XID       Secondary transmits XID
BA,I-P ------>                  Primary  transmits  I
etc.
```

Conflict Resolution

Although unlikely, there is a possibility of the occurence of conflicting requests during the link establishment phase. This is not possible during other link phases. A conflict occurs if two nodes try to initiate a link with the other at the same time but with conflicting requirements. For example, one node wants to establish a half-duplex link while the other wants to establish a full-duplex link or the protocols they want to use are different. Even if both sides take the same recovery action this still does not solve the problem. One side must gain the upper hand. The resolution method chosen is that the node with the higher address gets its way and the node with the lower address must report to its higher level that a link was established but not with the desired specifications due to conflict.

Disconnect frame (DISC)

The DISC frame is only sent during the link termination phase and it is the only type of frame that can be sent on links in the termination phase. I think this frame would better be called 'Unlink' because that is a better description of the function it performs. Connections (in my opinion) are the concern of higher protocol levels - not the datalink level. The DISC frame is only sent after the link has been established and indicates that the originator will no longer send or receive I and S-frames on the link. It is sent with the Poll bit on by the primary node (The node initiating the link termination) and sent with the poll bit

off by the receiving secondary node to indicate that it will no longer send I and S-frames on the link.

The format of the DISC frame is the same as that of the XID frame described above except that the usage of the P, T and R fields is different. In the DISC frame the Reason field (R-field) indicates the reason for the disconnect when sent with the Poll bit on by the primary node. If the R-field has no bits turned on this is a normal link termination but if a bit or bits are on in the R-field, then this link is being terminated because of an error. The R-field bits are defined as follows:

Bit number	7	6	5	4	3	2	1	0
	0	0	0	0	Z	Y	X	W

Where:

1. If W is on, the originating node has received an invalid or non-implemented control field.

2. If X is on, the originating node has received a frame with a prohibited I-field.

3. If Y is on, the originating node has received an I-frame with a length greater than the maximum the node can support.

4. If Z is on, the originating node has received a frame with an incongruous Nr.

If any of the bits are on in the R-field, the P-field contains the control field of the frame received which caused the error condition and the T-field contains the following information:

Bit number	7	6	5	4	3	2	1	0
	Vr			0	Vs			0

Where Vr is the next expected Ns value to be received and Vs was the next Ns value to be sent at the time the error was detected.

The P,T and R fields are undefined (and should be ignored) in a DISC frame with the Poll bit off. Similarily, the P and T-fields are undefined in a DISC frame with a value of 0 in the R-field.

Even though the node names are unnecessary from a technical point of view in the DISC frame, they are included in the Amateur Radio environment to give information to other nodes monitoring the channel as to who the two nodes are who have terminated the link between them. The names are also sent out when the link is being established as well. This is somewhat similar to the Amateur practise of identification at the beginning and end of each QSO.

Unnumbered Information Frame (UI)

The UI-frame is included in this protocol as a method of transmitting information when a link has not been established or for bypassing the normal handling of I-frames when a link is established. One example of such use would be a repeater identifying itself every few minutes - a type of broadcast message. It is included in the protocol because of a need in the Amateur Radio environment for such a function.

Since UI-frames are unnumbered, they should not be acknowledged whether or not they are transmitted with the Poll bit on or off. If one is lost, there is no way of recovering it. No error reporting is done for UI frames and the UI frame should only be passed on to a higher level when the data link is not established, not being established and not being terminated. For use as a type of general broadcast, the link address field in a UI-frame should use the special general broadcast address of FFFF (Hexadecimal) as the first two bytes of the link address. If the broadcast is only intended for a specific area then the first byte should be FF and the second byte should be an area or group number. And if it is intended for a specific node then that node's address can be used in the first two bytes.

Responses to polls

When a node receives a frame with a P-bit on, it must respond. The type of response varies depending on the type of frame that contained the P-bit. The response frame does not have the P-bit on except in the case of the I-frame response where the P-bit is allowed. The responses possible for each type of frame containing a P-bit are shown in Figure 4 following:

Polling Frame Type	Responding frame(s)
I	I or RR or RNR or REJ*
RR	I or RR or RNR
RNR	RR or RNR
XID	XID
DISC	DISC
UI	none
REJ*	I

* = REJ only used in full-duplex

Figure 4. Poll Responses

HALF-DUPLEX PROCEDURES

Half-duplex links assume that only one side transmits at a time. For this reason they can be used on a single two-way communications channel. Half duplex protocols can also be used on independent transmission channels as well but full-duplex would be a more efficient method when these facilities are available. Channel sharing with multiple nodes require half duplex protocols. V-2 provides a half-duplex multipoint protocol. This protocol can be used in a point-to-point environment as well with very little reduction in efficiency compared with a protocol only designed for point-to-point work.

Information transfer

When a node has one or more I-frames to send, it sends them in sequence and in conformity with the requirements described in "Frame numbering" previously. Since I-frames always require a response, the P-bit is turned on in the last frame of the transmitted sequence of I-frames. The exception to this rule occurs when it is necessary to transmit an S-frame with the P-bit on in the same transmission as well. In either case, a receive timeout is started at this time as previously described in the section, "The Poll bit and receive timeout". The node then turns the link around and listens for a response. Note that the reception of an I-frame with or without the P-bit on demands a response.

If the receive timeout expires, meaning nothing was received, the node will not retransmit the previous frames but transmit an RR or RNR frame with the poll bit on and again wait for a response. This operation repeats itself until something is received from the other side. (The higher level of protocol is notified after every N1 consecutive timeouts.)

When a response is received, the node starts transmitting I-frames again, beginning with the first unacknowledged I-frame.

Not ready condition handling

When a node becomes not ready to receive I-frames on a link it will send an RNR frame with the poll bit on at the earliest opportunity. If permitted by the other side, I-frames may be sent along with the transmission of RNR but only the RNR frame should have the poll bit on in this case and it should be sent last in the transmission. The node then listens on the link.

If the receive timeout expires, only the RNR frame with the poll bit on is retransmitted. If an I-frame is heard the RNR frame with poll bit is retransmitted. (Note - the node may accept or ignore the I-frame at its discretion even though it is trying to tell the other side to stop sending them.)

If an RR or RNR frame with the P-bit on is heard, the node should respond with I-frames followed by an RNR frame with the P-bit on if it can send I-frames or otherwise by transmitting an RNR framewith the poll bit on. Finally, if an RNR or RR frame with the P-bit off is received this will be accepted by the node as an indication that the other side is aware of the not ready situation and the node can go back to sending I-frames if it has any to send and is permitted to send them. Most of these actions can be deduced from Fig. 4 above.

Note that no node is permitted to send I-frames after receiving RNR and before receiving RR.

Ready condition handling

When a node becomes ready to receive I-frames on a link it will send an RR frame with the poll bit on at the earliest opportunity. If permitted by the other side, I-frames may be sent along with the transmission of RR but only the RR frame should have the poll bit on in this case. The node then listens on the link.

If the receive timeout expires, only the RR frame with the poll bit on is retransmitted. If an RR or RNR is heard with the poll bit on the node should respond by either transmitting I-frames followed by an RR with the poll bit on or otherwise by transmitting an RR frame with the poll bit on and start a receive timeout. If an RNR or RR frame with the P-bit off or an I-frame is received this will be accepted by the node as an indication that the other side is aware of the ready situation and the node can go back to sending I-frames if it has any to send and is permitted to send them.

FULL-DUPLEX PROCEDURES

A full duplex link requires two independent channels for the transfer of data. The full duplex protocol is designed so that it is possible for both sides to continuously transmit data to the other side simultaneously. One channel is used for transmissions by node A for example and the other channel is used for transmissions by B. Because of the potentially continuous nature of these transmissions, it is usual that each node never listens on its own transmitting channel. However, a node may delay its transmissions if it has some way of knowing that its transmitting channel is unuseable.

This version of V-2 only defines a point-to-point full-duplex protocol. This has uses in 'backbone' linking for an Amateur Radio digital communications network and for satellite work. It is an option which does not have to be implemented in all nodes. Extensions to V-2 for multipoint full duplex operation are being planned but are not within the scope of this paper.

Information transfer

In full-duplex each node listens even when transmitting. Frame numbering and acknowledgment is similar to half-duplex except that acknowledgments are done 'on the fly' even while the other side is transmitting.

A node sends I-frames in sequence until it either has no more frames to send or there are 7 frames outstanding. At this point it will put the P-bit on in the final frame to request acknowledgement from the other side and begin a receive timeout. In order to improve throughput on links with a long turnaround delay - such as satellites, it is permissible to put the poll bit on in a frame before 7 frames are outstanding and still continue to transmit up to the maximum of 7 unacknowledged frames. This technique is called 'pacing'.

If the receive timeout expires meaning nothing was received, the node will not retransmit the previous frames but transmit an RR or RNR frame with the poll bit on and again wait for a response. This operation repeats itself until something is received from the other side. (The higher level of protocol is notified after every N1 consecutive timeouts.)

When a response is received, the node starts transmitting I-frames again, beginning with the first unacknowledged I-frame.

If a node receiving sequenced I-frames encounters a frame not in sequence it should send a REJ frame at the earliest opportunity it gets. The node receiving the REJ

should go back to transmitting the last unacknowledged frame and continue from there. The node should not transmit any more REJ frames until the reject condition is cleared by the receipt of the numbered I-frame indicated in the REJ frame.

Not ready condition handling

Not ready conditions are handled similarly to that described in the half-duplex environment except that the channel doesn't have to be turned around.

Ready condition handling

Ready conditions are handled basically the same as described in the half-duplex procedures.

THE BIG PICTURE

The datalink layer of protocol described herein is only one part of a complete communications protocol. As per the suggested ISO protocol layering structures, this protocol only interfaces with the two adjacent layers in the node in which it is running and with the datalink layer on the other side of the link.

The datalink layer receives data and orders from the Network layer immediately above it. The network layer is a 'higher' level of protocol and sort of acts like the datalink layer's 'boss'. The datalink layer acts on these commands and reports on its progress and status as the job is done. When unusual conditions occur which the datalink layer can't handle it goes to its 'boss' for advice.

The datalink layer passes data and commands to the next lower protocol layer - the Physical layer which in the Amateur environment is usually the HDLC Controller chip. The physical layer acts on the commands from the datalink layer and returns data and status information to the datalink layer by means of status lines and interrupts.

The datalink layer also communicates to the datalink layer on the other side of the link.

Even though it is only the third of these interfaces which is the subject of this paper, it should be realized that in a real implementation of a datalink protocol there are actually three different protocols involved: i.e. the three communication interfaces. The type of protocols used for adjacent level communication are very system dependent but I will discuss in a general way, the type of information that is exchanged between the Network and Datalink layers.

Interface with the Network layer

Commands to the datalink layer and data to be passed accross the link are passed from the network layer to the datalink layer. The basic commands needed are:

1. Link - This is a command which orders the datalink layer to establish a link. The data passed with this command indicates what type of link (either Full or Half Duplex) is desired and the node name of the node to be linked to.

2. Unlink - This is a command which orders the datalink layer to terminate a link.

Status information and information received from the link in I-frames are passed to the Network layer from the datalink layer. The following status information should be passed:

1. When a datalink becomes established. The type of link and node name should be passed as well.

2. When a datalink is terminated. The reason code and node name should be passed as well.

3. Whenever a predetermined number of consecutive timeouts (N1) on a link has occurred.

4. When an invalid frame is received on a link.

The above lists are not necessarily complete but should serve to give the reader a good idea of the type of information needed. Each implementation will have its own method of handling these interfaces and it is not the intent of this paper to give detailed information as to how the information is to be passed.

SAMPLE EXCHANGE

The following example shows a V-2 exchange with no errors or exceptional situations encountered. It is beyond the scope of this paper to show an example of all possible types of exchanges. It is hoped that the information in this paper will be sufficient for the reader to determine what the exchanges would be when receive timeouts, lost frames, invalid frames, and colliding frames are encountered. The A,C and I-fields are shown separated by commas. The address field is displayed in hexadecimal. The control field is represented as follows:

T (Ns) P (Nr)

Where T is the frame type acronym and P is the poll bit. The (Ns) and (Nr) are only shown for frames which contain them and the P is only shown if the poll bit is on (1).

The Network header sub-field in the I-field in I frames is shown in Hexadecimal characters and the rest of the I-field is shown in ASCII characters. The subfields in XID and DISC frames are shown separated by commas, the node names being in ASCII characters and the P, T and R fields in Hexadecimal. Time progresses downward in the following charts.

The communication is between two nodes. Here is the pertinent information about the two nodes.

Call sign	VE7APU1	KA6M
Node number	627B	68ED

Exchange 1.

This example shows link establishment, information transfer and link termination. A complete QSO. Arrows to the right indicate transmissions from VE7APU and those to the left indicate transmissions from KA6M.

```
68ED627B,XID-P,VE7APU1,KA6M    ,P=01,T=00,R=00 ----->

         <------- 627B68ED,XID,KA6M    ,VE7APU1,P=01,T=00,R=00

68ED627B,I(0)P(0),0100,Hello Hank ----------------->

         <--------------- 627B68ED,I(0)P(1),0100,Goodbye Doug

68ED627B,RR(1) ------------------------------------>

68ED627B,DISC-P,VE7APU1,KA6M    ,P=00,T=00,R=00 ---->

         <------ 627B68ED,DISC,KA6M    ,VE7APU1,P=00,T=00,R=00
```

The first line shows VE7APU has entered the link establishment phase at request of the Network level and is trying to initiate (Poll bit is on) a half duplex link (Link Type = ØØ) with KA6M using version Ø level protocol (Protocol = Ø1). Because the Poll bit is on we know VE7APU has started a line timeout.

The second line shows KA6M has entered the link establishment phase and is responding (the Poll bit is off) positively (the Reason field = ØØ) using version Ø level protocol. When this frame is received, VE7APU will enter the information transfer phase and cancel the line timeout.

The third line shows VE7APU sending an I-frame with data to KA6M and demands a response from KA6M (the Poll bit is on). VE7APU starts a line timeout at this time. When KA6M receives this frame it will enter the information transfer phase.

The fourth line shows KA6M sending an I-frame with data and acknowledging correct reception of VE7APU's I-frame (Nr=1). It is demanding a response from VE7APU and starts a line timeout.

The fifth line shows VE7APU acknowledging KA6M's I-frame by sending a Receive-Ready (RR) frame with Nr set to 1. It has cancelled its receive timeout. The Poll bit is not on so VE7APU is not demanding a response from KA6M and so does not start a line timeout. VE7APU could have sent an I-frame at this point if it had any information to send.

The sixth line shows VE7APU has entered the link termination phase on orders from higher levels and is sending a DISC frame to KA6M to request termination of the link. The termination has not been caused by an error condition because the Reason field is ØØ. VE7APU is demanding a response from KA6M and starts a receive timeout.

In the last line, KA6M enters the link termination phase when it receives the DISC frame and responds (Poll bit is off) with a DISC frame. After transmitting this frame, KA6M goes into the unlinked state.

Since there are no further transmissions on the link we know that VE7APU has received the DISC, cancelled its receive timeout, and gone into the unlinked state.

RESTRICTIONS AND LIMITATIONS

1. This protocol will not function correctly if a node in the information transfer phase can hear frames from another node which is also in the information transfer phase and is using the same four-byte link address. Note that this would require two pairs (4) of nodes active on the same channel each pair using the same node number. One node from each pair would have to be linked with one node from the other pair. The probability of this situation arising is extremely low. (Somewhat similar to the probability of the FCC or DOC issueing the same call to two different stations!). According to my recollection of probability theory, probability of any conflict is:

$$\frac{N(N-1)}{(2^{16}-2^{8})^{2}}$$

where N is the number of active links on the channel. Note that the probability is reduced even further if not all nodes can hear every other node.

2. Although multiple links are allowed, a link will not be established to two nodes with the same address at the same time. The reason the link is not established is passed to the other node and corrective action could be taken - perhaps by changing the call sign suffix.

3. Multiple links between the same nodes are not allowed. The need for this feature is questionable as all necessary data traffic accross the link should be able to be multiplexed by the higher levels of protocol. Although not defined in this protocol, a node could masquerade as a different node by supporting multiple node addresses and names by changing the call sign suffix.

4. This protocol only supports datalinks between pairs of nodes. Thus it does not support conferencing or roundtable communication among a group of nodes. This function is normally provided by higher levels of protocol. The complications and problems encountered in providing data integrity with this service at the datalink level are severe and I do not know of any commercial or Amateur datalink protocols which do this. However, a form of roundtable operation could be implemented which does not guarantee data integrity. Each node in the group could operate in unlinked mode transmitting and receiving data in UI frames. The members of the group could agree to all use a broadcast address FFxx (where xx=a group number) in the destination part of the link address and then only pass information from frames which had a link address of this form. Members of the group should be in good communication with each other because there is no way of recovering data from lost frames when using this method of conferencing.

IMPROVEMENTS OVER THE OLD VANCOUVER PROTOCOL.

1. Both full and half-duplex links are provided for.

2. Multiple links are supported.

3. Some multiple protocol support.

4. Vastly increased number of link and node addresses.

5. No coordination of node addresses is required.

6. A rudimentary conferencing system is provided.

COMPARISON OF V-2 AND AX-25

I am including this section because I am sure that many people will make comparisons and also because AX-25 is the only other Amateur Radio packet protocol which has a published specification document.

This comparison is difficult to do because despite statements in the literature that AX-25 is a link level protocol, it is, in fact, a type of network level protocol. AX-25 routes packets through a series of links from a source node to a destination node. Although AX-25 provides end-to-end flow control, sequencing and data integrity, it provides no link level error recovery, retransmissions, acknowledgements, sequence checking, etc. for any of the links in the chain. Only in the special case where the source and destination are connected by a single link could AX-25 be construed to be a link level protocol. In this special case, the end points of the connection become identical to the end points of the link and so the end-to-end connection facilities cannot be distinguished from the link facilities. Some comparison of the two protocols can be done when considering this special case.

A document describing a Network level protocol for V-2 will be published later. Routing of packets through a network is one of the responsibilities of the Network level. Code for a Network level is being written at the present time for the VADCG TNC. Code for this link level protocol has already been implemented on the VADCG TNC.

1. V-2 has a reduced protocol overhead compared to AX-25. A 4-byte fixed length address field as opposed to a 14-byte or greater address field in AX-25.

2. V-2 has a facility to select full-duplex or half duplex protocols at link establishment.

3. V-2 has a facility to select different protocols at link establishment.

4. V-2 uses an addesssing and naming system for nodes. AX-25 makes no distinction between names and addresses.

5. AX-25 has a network routing system. V-2 link level does not.

6. V-2 does not bit shift call signs and other names when transmitted.

7. V-2 makes use of the selective receive function of the SDLC/HDLC protocol controller chips to automatically eliminate frames that do not need to be checked. AX-25 cannot do this. For example, in this area, all call signs start with the character 'V'. Using AX-25, this would mean that all frames transmitted in this area would have the same character after the initial flag in every frame. This effectively renders useless the selective receive function present on the protocol controller chips and forces the software to read into memory and examine every frame that is transmitted on the channel.

SUMMARY

The general specifications of the V-2 protocol have been presented in this paper. As this is the first draft of a new protocol, some details may have been omitted. This document will be revised as necessary, to expand on areas not clearly presented and to include changes in the protocol. Those interested in obtaining the latest version of this document should contact the author. Anyone having questions or comments should do the same, preferably by writing.

At the present time most of this protocol has been implemented in the VADCG TNC. The source code for this implementation is available on CP/M 8-inch diskettes. Anyone wishing to implement it on another system should contact the author directly so that the work may be coordinated.

The author feels that V-2 link level is an efficient protocol both in terms of channel utilization and software requirements and that it is particularly suited to the Amateur Radio environment. It provides almost all the functions required by the ISO data link model without overstepping into functions in the domain of other layers. It is intended as a building block upon which higher levels of protocol can be independently developed as per the ISO proposals.

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3. Fox, Terry "AX-25 Level 2 Protocol" Second ARRL Amateur Radio Computer Networking Conference proceedings, March 1983

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APPENDIX A. Node Address Calculation

The CRC-16 (16-bit CRC) algorithm divides the 7-byte character string of the Node Name by the following generating polynomial:

$$X^{16} + X^{12} + X^{5} + 1$$

This is the same polynomial used in calculating the FCS field by the various HDLC/SDLC protocol controller chips. In the calculation, integer quotient digits are ignored and the 16-bit remainder is checked to see that the first byte is not FF (Hexadecimal) and if it is, the bytes are reversed. If the first digit is still FF the value used is 0000. This playing around with the value is done to ensure that none of the special purpose addresses beginning with FF are generated.

Many of you out there may find this a little difficult to understand so I am including a sample assembly language program listing below which actually does the above generation for an 8080 microprocessor. It should not be difficult to implement in other processors.

Program Listing.

```
; ROUTINE TO GENERATE A NODE ADDRESS FROM A NODE NAME
; WHEN CALLED, IT USES THE NODE NAME AT LOCATION 'NODENM' AND
; LEAVES ITS NODE ADDRESS AT 'CRC' UPON RETURN
; IT DOES NOT GENERATE ADDRESSES WITH FF AS THE FIRST BYTE

0000             ADRCALC:ORG     0
0000 210000              LXI     H,0       ; INITIALIZE CRC
0003 225100              SHLD    CRC       ; FIELD TO 0000
0006 215300              LXI     H,NODENM; POINT TO NODE NAME
0009 1607                MVI     D,7       ; NO. OF CHARACTERS
000B 7E          LOOP:   MOV     A,M       ; GET A CHARACTER
000C CD2D00              CALL    CALCCRC ; GIVE IT TO CRC RTN
000F 23                  INX     H         ; POINT TO NEXT CHAR
0010 15                  DCR     D         ; FINISHED ALL CHARS?
0011 C20B00              JNZ     LOOP      ; NO, GO BACK
0014 2A5100              LHLD    CRC       ; GET THE CRC
0017 7D                  MOV     A,L       ; IS FIRST BYTE FF?
0018 FEFF                CPI     0FFH
001A C0                  RNZ               ; NO, RETURN WITH ADR
001B 7C                  MOV     A,H       ; YES, BAD LUCK,
001C 6F                  MOV     L,A       ; REVERSE THE BYTES
001D 26FF                MVI     H,0FFH
001F 225100              SHLD    CRC
0022 7D                  MOV     A,L       ; NOW IS FIRST BYTE FF?
0023 FEFF                CPI     0FFH
0025 C0                  RNZ               ; NO, RETURN WITH ADDRESS
0026 210000              LXI     H,0       ; YES, BAD LUCK
0029 225100              SHLD    CRC       ; SET ADDRESS TO 0000
```

```
002C C9                 RET             ; AND RETURN, END

      ; THIS IS THE ACTUAL CRC-16 CALCULATION ROUTINE
002D E5         CALCCRC: PUSH   H
002E 0608               MVI     B,8
0030 4F                 MOV     C,A
0031 2A5100             LHLD    CRC
0034 79         CALCCRC1: MOV   A,C
0035 07                 RLC
0036 4F                 MOV     C,A
0037 7D                 MOV     A,L
0038 17                 RAL
0039 6F                 MOV     L,A
003A 7C                 MOV     A,H
003B 17                 RAL
003C 67                 MOV     H,A
003D D24800             JNC     CALCCRC2
0040 7C                 MOV     A,H
0041 EE10               XRI     10H
0043 67                 MOV     H,A
0044 7D                 MOV     A,L
0045 EE21               XRI     21H
0047 6F                 MOV     L,A
0048 05         CALCCRC2: DCR   B
0049 C23400             JNZ     CALCCRC1
004C 225100             SHLD    CRC
004F E1                 POP     H
0050 C9                 RET

0051 0000       CRC     DW      0       ; NODE ADDRESS
0053 5645374150NODENM   DB      'VE7APU1'       ; NODE NAME

005A                    END
```

RECEIVED
A.R.R.L.#2
1984 AUG 30 AM 10:

9531 Odlin Road,
Richmond, B.C.
Canada V6X 1E1
August 23, 1984

Paul Rinaldo, W4RI
Manager, Technical Dept.
Americal Radio Relay League
225 Main Street
Newington, CT 06111

Dear Paul,

I see that the issue of using TCP/IP has come up again and so I am sending you a copy of a letter I wrote to Hank Magnuski re this subject early last year. Hank said that he thought my letter should receive wide distribution but I believe it was not distributed. In any case, the subject that it deals with is once again being discussed and so I think it would be appropriate to copy it to the committee for consideration at the forthcoming meeting. It may fall on ears that are receptive now.

I am including a copy of Hank's original suggestion in case you have mislaid yours. Hank made his suggestion way back in 1981. So you see, Phil Karn's, "radical suggestion" is not so radical after all.

As you can see from my old letter I am in general agreement with Phil on the use of the DoD TCP. It has a lot of good features but I would not copy it exactly but adapt it to our needs. See the section about 'Adapt not Adopt' in my letter.

As for the use of DoD IP, I think it could be adapted to our use as well. The 32-bit address is only a problem if we adopt this system, not if we adapt it.

Referring to AX-25, Phil says, "... what we call our Link Level Protocol is actually an end-to-end stream protocol analogous to TCP." I tried to say exactly the same thing to Harold Price and Terry Fox at the Trenton meeting earlier this year but only succeeded in alienating Harold.

Phil's letter makes several points I have been preaching for years but my words have usually fallen on deaf ears. Some points that need a loud, "Amen" are:

"I feel that we really do need link-to-link acknowledgements on long haul packet radio networks ..."

"Above the level 2 connections, there would be a single packet switch, relaying IP datagrams between the various logical links at level two." This is a restatement of a proposal I made way back in 1979. This is part of the original design of the VADCG network architecture worked out in 1978-79. I used terminology from a slightly different discipline and called the

packet switch a 'station node'.

I am strongly in favour of heirarchical addresses as was planned in the original VADCG network structure. That system used a two level addressing structure but for a world-wide network, a three or four level addressing structure will likely be needed.

Although somewhat dated, my article, "Network Architecture and Protocols for a Widespread Amateur Digital Communication Network" should be dusted off and made available for the committee considering level 3. It is contained in the first ARRL Amateur Radio Computer Networking Conference Proceedings - Vol 2. It has a number of points which are brought up repeatedly.

For people thinking about level 3 and up it would be a good idea to look at IBM SNA for some ideas. It is certainly not suitable for adoption or even adaption but contains a number of good features which should be considered.

My opinion is that we should look at all other network level protocols for ideas and use these ideas to develop a network level protocol for our special needs. X.25 level 3, IBM SNA, DoD IP etc. all have some features we need and others we don't. To be more specific and to risk some abuse, I would like to say that the adoption of X.25 level 3 as a standard for amateur packet radio would be a big mistake.

Unlike IBM SNA or TCP/IP which are network communication protocols, X-25 is only intended to be used between an end user or subscriber and the entry point of a network. It is only designed for getting into the network, not for use in the network itself. The network itself uses a different protocol. To put it another way; do you remember the diagrams showing an X.25 network in the literature? The diagram showed all the users connected to a big cloud with a line called X.25. The cloud represents the network. In actual networks the X.25 protocol is not used internally. The protocol used internally in the network is what we need, not the entry protocol. If we adopt X.25, we will still be faced with the task of implementing another protocol to represent the big cloud. X.25 does not have the addressing/routing system used within the cloud which is what we need.

73, Doug

Douglas Lockhart, VE7APU

27 Shamokin Drive,
Don Mills, Ont. M3A 3H7
February 12, 1983

Hank Magnuski, KA6M
311 Stanford Avenue
Menlo Park, CA 94025

Dear Hank,

This is in reply to your letter to Paul Rinaldo of June 10, 1981 a copy of which was sent to me and 11 others. It has been a while but I am finally responding to it. Paul has been faithfully distributing such correspondence and I am sending him a copy of this letter so that it may reach those who received your original letter.

When I received your letter from Paul I was heavily involved with the ANIK-B satellite link with Ottawa and the end of that overlapped with my move to Toronto so the reply got pushed way down my priority stack and finally got lost. All these and other considerations have been resolved and it now looks like I will be able to become increasingly more involved with Amateur Packet Radio in the future.

The subject of inter-network protocols has become more of a concern to me recently because I have begun work on implementation of a Transmission Control Protocol on my CP/M system and VADCG TNC and a part of this work is the subject of my paper at the forthcoming conference. I have reviewed all my correspondence and I have only been able to find one other response to your request for comments and that was from Stu Beal, VE3MWM whose response dealt mostly with the general philosophy of such protocols and not much with the details. I would be pleased to hear of any other written responses you received, if any. After publishing my suggestion regarding protocols in the proceedings of the first conference, I expected to get some correspondence but I received none so I would not be surprised to hear that Stu's response was the only one you got..

Maybe I can find an excuse for not replying to your letter found in your letter itself. On the bottom of page 2 you say, "...I would like to see some comments on why we shouldn't use it." Well, I think we should use it, so perhaps it could be construed that I should not be commenting. (Please note that this paragraph is intended as humour.)

My protocol suggestion dealt mainly with the Transmission Control Protocol and very little with the Inter-network protocol although the TCP (Transmission Control Program) must interface with the inter-network protocol. I need to implement a TCP which will be able to provide all the information the inter-network protocol requires to function even though the inter-network protocol is only required when information is entering or leaving the network. My hope was to get agreement on a Transmission Control Protocol which would mean that an inter-network

protocol would only need to be used when communicating with non-Amateur networks (foreign networks). The agreement on a TCP protocol would allow communication between application programs and permit the application programs using the network to be written.

The development of the Inter-network protocol before anyone has developed a TC protocol has some dangers. It tends to stress the differences between the networks rather than trying to make them talk to each other. Or, in other words, it tends to create a lot of separate networks rather than one large network. Also, while two users can communicate successfully when they only have a TC protocol, it is not true that they can communicate successfully if they only have an Internet protocol. Here is an analogy that might make the above point a little clearer. Suppose we set up a telephone system so that we could dial up telephones in China - unfortunately we still couldn't communicate because everyone there talks Chinese and everyone here talks English. Maybe my analogy isn't perfect but I hope I made my point. My efforts at developing a TC protocol is like getting everyone to learn Esperanto and the Internet protocol is like trying to get everyone to construct their part of the telephone network referred to above. Which development should come first is a matter of debate. I guess the best of all would be to develop them together at the same time with some kind of an integrated approach. One without the other won't solve the total problem.

Before discussing your proposals I would like to point out an error in the DoD Internet Protocol document that I have discovered. I consider it to be a very significant mistake that may cause some confusion to the readers. In section 2.2 titled, 'Model of Operation' the text says 'The sending application program prepares its data and calls on its local internet module to send that data as a datagram and passes the destination address and other parameters as arguments of the call.' This is incorrect and contradicts statements and the diagram in the immediately preceding section (section 2.1). It also contradicts statements in section 1.3 of the same document. The application level is the highest level and there may be several protocols in between the application level and the internetwork level - such as the TCP. The diagram in 2.1 shows this structure correctly. There never should be direct communication as described between the application layer and the internetwork layer. Section 2.1 says, 'Internet protocol interfaces on one side to the higher level host-to-host protocols and on the other side to the local network protocol.' This is correct. Section 1.3 says "For example, a TCP module would call on the internet module to take a TCP segment (including the TCP header and user data) as the data portion of an internet datagram. The TCP module would provide the addresses and other parameters in the internet header to the internet module as arguments of the call. The internet module would then create an internet datagram and call on the local network interface to transmit the internet datagram." This is also correct and contradicts the statements made in 2.2. Section 2.2 persists in this error and shows the same error in its Figure 2. and also states, "The internet module determines that the datagram is for an application program in this host. It passes the data to the application program in response to a system call, passing the source address and other parameters as results of the call." These statements are also incorrect. I am guessing, but I think the author of section 2.2 was confusing the application programs with

the transmission control program. My recommendation is to ignore everything in section 2.2.

I am in very strong agreement with you on all your major points and I would like to even go one major step further and suggest that we also adopt a version of the DoD Transmission Control Protocol. It contains some excellent ideas and suggestions of methods and is very complete. I am planning to make a proposal around this protocol soon in a separate document. Now I will comment on the major points of agreement.

- The 'datagram' is the only practical way of providing inter-network communications. A 'virtual connection' approach is out of the question because some of the networks Amateurs will want to communicate with or through will not be able to provide this facility and also because any packets that have been sent out of one network to another pass beyond control of the originating network. Once out of control of the originating network, it is impossible for that network to make any guarantee as to the sequence of packets that will arrive at the destination or whether they will arrive or whether any indication that they have or have not arrived will be returned to the originator. Please note that the above comments on inter-network datagrams does not apply to intra-network communications. Each network is still free to use either the datagram or virtual connection methods (or even both) for its own internal communications. I am not sure that this latter point is made clear in your letter. I am frequently guilty of confusing this point when I refer to a world wide Amateur Radio Digital Communications Network which will probably turn out to be a large group of networks communicating with each other. (A 'catanet')

I too agree with your proposal, "I propose that AMNET and AMICOM adopt the INTERNET standard intact, with a couple of minor extensions to solve some of our special problems." I have a slightly different idea as to how to solve these recognized problems which I will describe later.

- I agree 100% with the several points mentioned in the paragraph headed 'First' on the second page of your letter.

In the next paragraph you say that it would make us compatible with DoD and some other networks to which we might eventually want to interface. This is only partially true because of the extensions you describe. The addressing requirements in the Amateur Radio networks and in the DoD and other networks are different as you say so it is necessary to use a gateway function of some kind when passing between these networks. Admittedly, the gateway would not have to be very complicated to do this job. This would allow us to pass packets through the DoD network and on to another amateur radio network. This pass-through function is quite a bit different from actually communicating with the hosts and users in the DoD network itself because that would require compatibility at the higher levels of protocol such as the Transmission Control Protocol. By providing a very simple bidirectional gateway function the amateur radio networks could reciprocally provide a pass-through function between two DoD networks as well. Both could provide a service for the other with no requirement of any knowledge of any higher level of protocol than the internet protocol. The gateway

would have to have knowledge of the addresses in both networks.

I agree with all the points raised in the paragraph which starts, 'Third' on the second page. The INTERNET document is one which we can build on. We both agree there are some changes required but the document is the best that we have available at the present time describing an internet protocol.

I also agree with all the points raised in the last paragraph on the same page where you bring up the question of Transmission Control Protocols. This is of course an entirely different subject which opens up a whole new set of considerations. I will be preparing another document on TC Protocols which will hopefully get more feedback than my last one.

On the third page you discuss the problems in applying the INTERNET standard to the Amateur Radio environment. I agree 100% with your identification of these problems in the area of addressing. The Amateur Radio environment must use call signs as at least part of the internet addressing/naming structure. I would like to propose a slightly different solution however.

The addressing structure you proposed has four components:

1. A single byte field containing a zero field or a constant for all the Amateur Radio networks.

2. A two byte field representing a geographic location to the nearest degree of latitude and longitude.

3. A one byte field assigned to each station in an area presumably assigned by a higher level of protocol or by committee.

4. A six-byte field containing the call sign of the station.

I propose an address structure with three components:
1. A six-byte field containing the call sign of the station similar to number 4 above.

2. A one byte ASCII field normally blank (20H) but will be used to represent different connections to the network by the same station. To quote the Internet Protocol document, "Care must be taken in mapping internet addresses to local net addresses; a single physical host must be able to act as if it were several distinct hosts to the extent of using several distinct internet addresses." Alternate physical and logical connections can be identified by changing this to another ASCII character or number. It can be looked upon as being part of the call sign for convenience for example: VE7APU1, VE7APU2, etc. A multi-homing feature can also be provided by ignoring this byte. I am not sure if this is what you intended by item #3 above.

3. A field representing the network or area that the station is in. The length of this field will be determined by the method of representation chosen as follows. (Choose only one.)

3.1. A one-byte network number chosen by committee. I would expect that 256 amateur radio networks would be enough for some time to come but..

3.2. A two-byte network number chosen by committee. This certainly would be enough for as far as I can see into the future.

3.3. A two-byte network number based on the geographical partitioning method described in your letter.

3.4. A three byte ASCII network name such as 'TOR' for Toronto or 'LAX' for Los Angeles. Something like airport naming. It may be used to identify foreign networks as well as areas or domains in the Amateur Radio network.

By giving a choice, I don't mean to leave everyone free to choose which one he wants to use. One of them should be chosen as a standard. I can live with any of them but I have a personal preference for choice 3.4 for the following reasons:

1. It's consistent with the other part of the address being a name that is readily understood by the end user of the system as is the call sign. It is very user friendly.

2. It will not require a look up table or directory on the part of the end user to make use of it as choices 1,2 and 3 will require.

3. I don't think that the internetwork naming and addressing is the proper place for routing information to be placed. In this respect I feel that we should not change the DoD Standard Internet Protocol. The routing system should be handled by another level of protocol and another mechanism. In the case of the DoD protocol standard it states that, "It is the task of lower level (i.e., local net or gateways) procedures to make the mapping from local net addresses to routes." The document does not deal with routing. I think the question to be asked is; 'Who are these fields going to be made convenient for - the user or the computer?' I think they should be made for the user. There are a number of other mechanisms that will work for routing.

The document states, "A distinction is made between names, addresses, and routes. A name indicates what we seek. An address indicates where it is. A route indicates how to get there. The internet protocol deals mainly with addresses. It is the task of higher level (i.e., host-to-host or application) protocols to make the mapping from names to addresses." As you will observe, neither of our proposals to solve the addressing problem pays strict attention to this discrimination. My solution uses names as addresses and so eliminates the need for higher level protocols to map names to addresses. This makes the 'addresses' longer however. The reason why I chose this way is because I thought as hard as I could and could not think of a practical way for separate networks to implement a mechanism whereby the names we need to use could be mapped to addresses. I assume that you did the same and came up with a similar conclusion judging by your proposal. The problem is that the call signs are so very important in the Amateur Radio environment but at the same time, they are too

randomly assigned and numerous. So I am taking the easy way out and calling them addresses.

To go back to the discussion of address compatibility and gateways. The addresses in one network are not compatible with those in another network just because they occupy the same number of bytes. In my proposal the addresses are obviously not the same length as those in the DoD network. Likewise in your proposal, the addresses are not the same length. You have hidden part of the address in the options field. I think the test for what part is an address is the answer to the question, "What parts of the header do I need to get the datagram to the destination host?" If you say the call sign is not part of the address because all the information is in the four byte field using the last byte to represent the call sign then the next obvious question is, "What mechanism is there for the source to learn the destination's four byte address without first using the call sign field to deliver the first datagram to the destination?"

The other problem is mapping the names to routes. There are a number of ways to do this. When the packet enters the network, the gateway can have a table mapping the names to routes. It only needs to map the three byte network/domain name to a route at this time because the call sign can be mapped when the datagram arrives at the destination network, area, or domain. In some situations it may not be necessary to map the call sign to a route at all. It may be sufficient to just broadcast the datagram in the local area where the destination will be able to hear it. This mapping task in many cases may be much simpler than it sounds depending on how the various areas of the network are linked together. For example in many cases there will be only one direction in which it is possible to transmit data so no mapping has to be done. So the datagram may be passed automatically along to where the mapping actually has to be performed. In other cases it will only have to be determined whether the datagram is for this area or some other area to decide whether to send it along or broadcast it locally. When a true mapping node is required it could insert routing information into the option field for this purpose. Very little route mapping will have to be done in actual fact until the time the network becomes extensive.

Even if two networks have the same length address fields and even if these fields contain sufficient information to get the datagrams to their destinations within each network, this still is not sufficient for compatability. Both networks must be able to understand the other address in order to be compatible. I will try to illustrate this using your four byte address scheme and a hypothetical situation where the Amateur network or networks is using the Arpanet to provide a pass-through facility between San Francisco and Washington, D.C. A datagram originating in San Francisco needs to be passed through the Amateur network in the San Francisco area, then into the Arpanet, through the Arpanet to the Washington, D.C. area, out of Arpanet and into the Amateur network in the Washington area and finally through the Amateur network to its destination in the Washington area. Using your address scheme everything will go fine until the Arpanet tries to move the datagram through its network. I don't know how the Arpanet determines routes from addresses but I am pretty sure it will have no way of handling the two bytes that represent geographic location to the nearest

one degree. The one byte network address won't help any either even if agreement with the DoD is obtained so they will recognize the address as belonging to an amateur radio network. To do this they will have to change the software in all the hosts in Arpanet and add code so they will understand the Amateur network addressing structure. The reverse situation is also true, the Amateur network does not understand the Arpanet addresses. The only practical solution to this problem is the use of a gateway as the internetwork protocol was intended to be used. The gateway has the ability to translate between the Amateur network addresses and the Arpanet network addresses - not necessarily all addresses but the ones we need to use. Making the addresses the same length in both networks doesn't really make this mapping process any easier. In fact it may make it more difficult because a four byte address may not be the most convenient length for the Amateur network. Please excuse me for perhaps belabouring the issue of compatability but it was suggested as one of the major reasons why we should adopt this protocol.

The Amateur radio network environment is unique. I think Stu Beal's observation when he quotes Kleinrock is very appropriate:

> "In our experiments ... we have occasionally attempted to adopt a protocol from one network directly over into a new network. We have found that this is a dangerous procedure and must be carefully analysed and measured before one adopts such a procedure. Indeed, the use of old protocols in a new environment is dangerous." (Kleinrock, op cit)

It looks like Stu has come up with a maxim for Amateur packet radio, "Adapt not adopt." It may be that we are doing too much adoption and not enough adaption in dealing with the DoD Internetwork protocol.

I think that intra-network routing should be the responsibility of the network concerned. In other words, when a packet from another network enters a destination network, that network should be able to deliver the packet to its destination using only the call sign in the internetwork header to direct it. The network I am working on uses a station node and will certainly be able to do this job and will also be able to send a message back if it cannot be delivered. However in the case where there is no real network, the internetwork packet can just be broadcast by the repeater represented by the network name, the station it is intended for will hear its call sign and respond. In this case however, no negative response will be provided if the station is not present to respond. (In true datagram fashion.)

To provide inter-network routing on the other hand, requires some kind of universal system that has to be agreed upon by the various networks to work. What that mechanism should be requires a major effort at agreement and should be the subject of a separate proposal. The alternative is the use of gateways.

I think I have commented on two of the four components of your proposal for addressing. The one byte network number field that is either zero or a constant yet to be assigned by the DoD I feel is entirely unnecessary and would only be of concern to the gateway function that interfaces with the DoD network. It is only useful while

the packet is actually passing through the foreign network and in fact all four bytes in the destination and source addresses will have to conform to the other network's standards while the packet is being handled by the DoD or other foreign network. i.e. this means the packet has been transformed by the gateway function. While it is on 'our' side of the gateway, this field is of no use.

In reference to the low order eight bits that will be assigned to stations in the same area: I feel that this one byte field is just a shorthand way of referring to the call sign field and so is redundant. The call sign uniquely defines the destination of the internet packet and is already present. The use of a shorthand form for the call sign has its uses in certain cases in intra-network communication however and the system I am working on will allow mapping of call signs to single byte addresses to use as link level addresses and shorten packet overhead by 10 bytes. But this function is not for the inter-network protocol. It should be kept a local matter in each network interface.

As to the format of the internet header: My proposal is to expand the source and destination addresses from four bytes to ten bytes each. (Assuming you use my preferred choice for the network address- otherwise, nine or eight bytes.) and change the version number from 4 to 5 for example. Now here's what happens when the packet is passed through the DoD network which needs a version 4 header.

The packet arrives at the gateway node to the DoD network, the gateway node takes the 10 byte Amateur network source address and puts it in the option field, it takes the 10 byte Amateur network destination address and puts it in the option field, changes the lengths of the address fields to four bytes and inserts the DoD network source address and the DoD destination address information and finally changes the version number to 4. The version 4 packet is passed through the DoD network to its destination which is another gateway to an Amateur Radio network. This gateway transforms the version 4 packet back to version 5 by getting the information from the option fields and the packet is passed through the amateur radio network to its final destination with no-one the wiser as to what happened. The transformation is a very simple matter. Whether or not the transformation is necessary, the gateway is still necessary to interface to the foreign network because knowledge of the addressing system of the foreign network must be kept somewhere and I don't think that users of the pass through facility should be required to have this knowledge. Also, some kind of physical interface is required as well.

You suggest reducing the complexity of the INTERNET standard by restricting the use of the fragmentation feature and you say,"The standard specifies a 576 byte maximum packet size." Actually the standard specifies that 576 bytes is the recommended minimum datagram size that will be accepted by a destination host. The maximum datagram size is 65,535 bytes. The standard recommends that datagrams larger than the minimum only be sent when it is known that the destination can handle them. This is only an agreement between source and destination and the implication is that all networks will be able to handle datagrams up to the maximum size either whole or by fragmenting them. In section 3.2 of the specification after the heading, 'Fragmentation and Reassembly." it says, "Every internet module must be able to forward

a datagram of 68 octets without further fragmentation." This implies that the network should not have to fragment a datagram unless it is over 68 bytes long. The LIPs we are using now meet this requirement because they handle packets as long as 250 bytes without fragmentation. I would agree with you in your proposal in this regard if it weren't for the possibility of the reverse situation occurring. You are mainly concerned with the Amateur networks making use of other networks such as the DoD network. What about the reverse situation where the DoD network wants to use the Amateur network? In this case our network would be receiving 576 byte packets destined for Amateur Radio hosts and potentially datagrams up to the maximum of 65,535 octets if the destination host is prepared to accept them. (see section 3.1 of the standard after the heading, 'Total Length:') The possibility exists that both source and destination hosts are in non-Amateur networks and the Amateur Radio network is only being used for pass-through. We would not have any control over the datagram size in this case. I think we'd better leave the fragmentation feature as it is if we want to interface with non-Amateur networks and advise all hosts to be able to handle datagrams up to 576 bytes if you envisage the situation where the source is in an Amateur network and the Destination is in a non-Amateur network or vice versa.

As far as the Service Type, Security Option, Stream ID, and Timestamps I agree that we do not need them but we must make provision for them in the gateway because packets coming out of the foreign networks we are using may require them even though we don't. We should make the gateway store these in the options when a packet comes into the Amateur network and return them to their proper location when leaving the Amateur network again. We can assign our own option numbers for this. I think the possibility of reciprocal use of other networks for pass through purposes should be maintained even though we may not be able to see the possibility immediately. For example, what if the DoD wanted to test the Amateur Radio network for possible use during an emergency situation? We wouldn't want them to lose their security information or to have our network refuse to deliver their 10,000 byte datagram or would we?

Some of the above comments are elicited by your own statement that we may want to interface with some already existing networks. I am mainly concerned with an Amateur network and I don't know how serious you are about using these other networks or what the possibilities really are but if you are really serious about it, we will have to make provisions for support for all the fields in the standard even if we don't use them ourselves for the benefit of these other networks. The full interfacing of these other networks to ours where we can access all the users and functions of a non-amateur network is not a trivial matter and requires analysis of all levels of protocol used in both systems and may prove to be impossible in some cases even with extremely complicated gateways. This is why I have mainly limited my responses to the use of these networks for pass through purposes. Your letter does not clearly explain the type of interface you envision.

Let me become philosophical for a moment. My original idea when I became involved with Amateur Radio Digital Communications was the creation of a purely Amateur Radio Digital Communications network

developed by Amateurs and for Amateurs using techniques and protocols tied directly to the needs of Hams. Unfortunately or fortunately, depending on your point of view, this pure ideal has not proven to be very popular. Many are concerned with interfacing or making the Amateur Radio network compatible with other existing networks. Interoperability has become a major desire expressed by many. In my opinion, by going this route, we are opening a large bag of snakes and limiting our potential at the same time. As for an Internetwork protocol, I think Amateur Radio needs to have one but at the same time I hope we never have to use it except for communication with a non-Amateur network. I can still hope even if I don't expect.

Finally, I would like to say that although I have some different proposals I don't consider them to be major objections to your own proposal for Amateur Radio's Inter-network standard. In fact, in the spirit of compromise, and at your insistence, I will agree to your original proposal in all details even though I don't think they may be the best solution. So there you have it, total agreement on your proposal if you want it. I only hope that you might after careful consideration see fit to adopt maybe one or another of my differing ideas expressed above. And now, since we have come to an agreement, maybe we can get some other group to agree on your proposal as well.

73 for now. I'll see you at the Conference in March.

Doug

Doug Lockhart, VE7APU/3

311 Stanford Avenue
Menlo Park, CA 94025
June 10th, 1981

Mr. Paul L. Rinaldo
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Dear Paul,

Thanks very much for your report on your meeting with the DARPA people, and for the information you sent on the INTERNET protocol, TCP and the packet radio article. I think the INTERNET specification deserves some serious discussion by our group, and the purpose of this letter is to review some of the merits of this standard and how it could be used as the basis of our experimental network.

First, the INTERNET protocol standard is based on the concept of a network which uses a "datagram" as the basic unit of exchange, the basic commodity which is transmitted through a net or between nets. Datagrams are nothing more than packets which have a source and destination address embedded in them and some other control information. The delivery of datagrams through a net is not guaranteed, but is done on a best effort basis. It is the responsibility of the end-to-end communicating processes to check that all outstanding datagrams have been received and correctly ordered, and these processes must be prepared for lost or duplicate datagrams. Much has been written in the literature about datagrams and how they form the fundamental building blocks of networks, and I won't repeat all the arguments here. Let me simply state that many current large scale networks have been built using the datagram concept, and we should not overlook this approach in our design.

About a year ago when I was studying the design of the AMSAT AMICON system, the INTERNET spec first came to my attention. My conclusion then, as you can tell from the first AMICON draft, was that a datagram approach was right for that system. I now would argue that it is also right for our terrestrial networks as well.

Recently I had several long discussions with two people who are professionally involved with computer networking and who are radio amateurs as well. One of these persons is Dave Boggs of Xerox, co-inventor of the Ethernet. Dave described to me how the corporate Ethernet is really a heterogeneous network of Xerox Alto and other types of computers, with links in the network going up and down on a daily basis, with constant changes of equipment and configurations, and with some of the network nodes left on continuously and with some nodes only running 9 to 5 or as needed. Thus, their environment is not drastically different from what we would expect to see in the amateur community, where stations come and go and where elements of the network may be very reliable or very flakey. Ethernet uses a building block called a PUP, which stands for PARC Universal Packet, and which is nothing more than a type of datagram. Dave is a very strong supporter of the datagram approach (almost a missionary) and encouraged me to study his paper describing the PUP (see the

April 1980 issue of IEEE Transactions on Communications). Well, it turns out that the INTERNET and PUP designs were one and the same several years ago, and the Xerox people had to split with the INTERNET community in order to tailor certain things for their own net and to get on with the job of implementing Ethernet in a reasonable timeframe.

The other person I talked to was Al Larson of SRI International, who has worked with INTERNET and has some idea of its usefulness and difficulty of implementation. I asked him about his reactions to using INTERNET as a standard for the amateur community and his response, in general, was very positive. We discussed several problems and limitations, and I will relate these later.

Well, let me get to the heart of the matter. I propose that AMNET and AMICON adopt the INTERNET standard intact, with a couple of minor extensions to solve some of our special problems.

First, this protocol is a standard, adopted by the DoD, ARPANET, and supported by many other major packet carriers. It represents the experience of ten or more years of computer networking and the contributions of hundreds of researchers and developers of packet technology. The specification is complete, a publicly available document (through NTIS), and can be used in a fairly simple way by our network. It provides us with the datagram building basis which I feel is important. It conforms to currently accepted practices of multi-layer network design, and could be used both on a national and international basis.

Second, it would make us compatible with DoD and some other networks to which we might eventually want to interface. Amateurs have had a long history of cooperation with the military (MARS, for example) and this would represent a continuation of that cooperation.

Third, it would save us an enormous amount of development time in bringing up our network. I'm really afraid that if we started with something much simpler, as some hams will encourage us to do, we would find in a year or two that features are lacking and extensions are necessary. Much discussion and haggling would produce a new and revised spec, and piece by piece we would eventually reinvent most of the features that are currently in the INTERNET document. I think it's much more reasonable to take this design and declare certain features as optional for our network.

Next, I have not seen any serious counter-proposals on how we should do networking, and I don't know who's going to find the time to write as comprehensive a document as this one.

Finally, I really think that the protocol would work for us, and serve our needs in a reasonably economical manner. The INTERNET protocol permits us to adopt TCP or some other set of end-to-end protocols in the next higher layer of the network. It allows us to use HDLC as the link level and local area network mechanisms for delivering packets to the end-user stations. It's compatible with what we need for the satellite net. It has some really neat features, and I would like to see some comments on why we shouldn't use it.

In looking over this document the application of the standard is fairly straightforward except for one area, and that concerns addressing. A four byte source or destination address is specified, and that does not meet our needs. The first byte of this four byte field represents a network, and about 40 of the possible 256 combinations are already assigned. I attempted to contact the author of the document to see if a number could be assigned to an amateur radio experimental network, or to see if there already was a number for personal computing networks, but John Postel was out of town, and I didn't get an answer to my question. It seems clear that 256 networks is somewhat limiting, and that some future revision of the standard will have to expand this field. In the meantime, we should assume that this field is reserved and not to be used by us, and if we don't get our own network number, we can set the field to zero.

Well, that leaves three bytes or 24 bits of addressing, a selection of 16,777,216 integers which can be assigned to unique entities in our network. That number is large enough to assign each amateur on earth a unique code. Doing that, unfortunately, does not help the routing problem very much because one would need a callbook type of directory to translate these digits into people or places. It also does not take advantage of the uniqueness of callsigns and our familiarity with and use of calls. I propose to utilize the 24 bit address field in the following manner:

> Addresses only have to be assigned to stations serving as network traffic processors, such as repeaters, gateways and mailboxes, and other individual stations do not have to have an address if they are accessible via a local net served by such a gateway or repeater.
>
> The high order 16 bits (65,536 integers) can be assigned to stations based on their geographic location. It turns out that 360 degrees longitude multiplied by 180 degrees latitude provides for 64,800 locations, just under the 65,536 permitted. The remaining low order 8 bits can be sequentially assigned to stations within the same geographic area. If all 256 slots are filled, the nearest open slot can be assigned. Numbers above 64,800 are reserved for satellite stations and special cases. This method of address assignment is both rational and allows repeaters to implement message routing without any prior knowledge of the location of the recipient.
>
> The callsigns of the sender and receiver will be located in the options field, using two of the unassigned control option numbers. Thus the packet header will consist of the standard 20 bytes plus 12 to 16 bytes of options containing the sending and receiving callsign. Explicit routing of messages is still permitted through use of the source routing option.

Some of the complexity of the INTERNET standard could be reduced by restricting use of the following features:

> Fragmentation - Breaking up a packet is not necessary if the buffer allocation is large enough. The standard specifies a 576 byte maximum packet size.

Service Type - This is an option which can be ignored. Useful for interactive vs. batch traffic, or priority message handling.

Security Option - Not required in our network.

Stream Id - Not required

Timestamps - Optional

When we eliminate the requirement for the above items, we really have a basic set of features which are needed for an easy-to-use and versatile network service. Some of the features, such as error reporting, will be necessary to help people figure out what's going on. Other optional features will be useful in testing and measuring network performance.

So, there's a proposal on the table. Can we get some comments?

Best regards,

Hank

Hank Magnuski, KA6M

COPIES SENT BY W4RI TO:

K8MM0	VE7APU	VE3MWM
WB4JFI	W1XX	WB5MMB
W1EH	W3OTC	W1UED
W4MIB	W4CQI	WB3KDU

THE AMERICAN RADIO RELAY LEAGUE, INC.

[illegible] SOCIETY OF THE [illegible]

ADMINISTRATIVE HEADQUARTERS: NEWINGTON, CONNECTICUT, [illegible]

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August 6, 1984

Mr. Robert Foosaner, Chief
Private Radio Bureau
Federal Communications Commission
Washington, DC 20554

In re: STA for Teleport Operation

Dear Mr. Foosaner:

The American Radio Relay League (ARRL) and the Radio Amateur Satellite Corporation (AMSAT) hereby request the Commission to grant special temporary authority (STA) to permit operation operation in the Amateur Radio Service as detailed below. The application is made on behalf of, and with the consent of, the individuals named herein.

NAMES AND ADDRESSES OF THE APPLICANTS

The names and addresses of the applicants are given in the attached letters of participation.

DESCRIPTION OF NEED

An STA is needed to cover "teleport operation" until such time that a permanent rule change is proposed. STA operation at this time will enable us to better define our needs prior to filing a petition for rule making.

TYPE OF OPERATIONS

The operations of the stations operating under the STA will involve communications with terrestrial Amateur Radio Stations and Amateur Radio stations in space operation. They will function primarily as intermediary stations between terrestrial and space Amateur Radio stations. We hereby designate these intermediary stations "teleports." This request for STA encompasses all of the Amateur Radio stations named in the attached letters of participation so that each of them, separately or in conjunction with any or all of the others, may conduct teleport operations.

Purpose:

The purpose of a teleport is to relay digital messages automatically between terrestrial Amateur Radio stations and amateur stations in space operation (amateur satellites). The need to do so is twofold:

(1) to obviate the need for every Amateur Radio station having a digital communications capability to also have an earth station capability in order to communicate with amateur satellites.

(2) to provide a measure of traffic-flow control for the digital channel(s) on the satellite(s). A teleport must operate in automatic control (without the requirement that a control operator be present) in order to provide maximum capability.

Objectives:

There are three primary objectives of this request for STA:

(1) to determine experimentally what equipment and techniques are required to provide near-real-time relay between two or more terrestrial stations using local teleports and an amateur satellite.

(2) to determine experimentally what is required to provide reliable store-and-forward communications wherein the teleport station buffer stores the messages between the hours that the satellite and terrestrial links are not available at the same times.

(3) to gather the necessary information for a permanent rule change to permit teleport operation.

DATES AND TIMES OF OPERATION

The applications request that operation under the STA commence immediately upon the granting of authority by the Commission, and that such authority be permitted for one year, with leave to renew the STA. There should be no restrictions as to the time of operations in order to permit the flexibility needed to comport with the varying orbits of Amateur Radio satellites.

CLASS OF STATIONS AND RADIO SERVICE

All stations are licensed in the Amateur Radio Service, and all licensees hold a minimum of a Technician class license.

LOCATION

The locations of the stations in teleport operation shall be from the fixed station location listed on the station licenses of the applicants, plus such portable operation as would be permitted under ordinary Amateur Radio operation.

NUMBER OF TRANSMITTERS

Each station in teleport operation will need two transmitters, one for communicating with terrestrial amateur stations and one for communicating with amateur space stations.

OPERATING FREQUENCIES

Satellite uplink	:	435-438 MHz and 1269-1270 MHz
Satellite downlink	:	144-146 MHz and 435- 438 MHz
Terrestrial inputs/outputs:		Any amateur frequency above 50 MHz where digital communication is permitted

OUTPUT POWER OF TRANSMITTERS

The maximum power will be governed by Section 97.67 of the rules and by power-sharing criteria for the amateur satellites.

TYPE OF EMISSION

F1 and F2 emissions are to be used.

DESCRIPTION OF ANTENNA

No special waiver of the rules is requested.

The American Radio Relay League (the nonprofit, educational and scientific organization representing the interests of the more than 400,000 licensed radio amateurs in the U.S.) and the Radio Amateur Satellite Corporation (the nonprofit, educational and scientific organization responsible for the development, launching and operation of the AMSAT-OSCAR satellite series) respectfully request that the Commission grant this request for special temporary authority. Statements of the individual amateur licensees involved are attached and incorporated in this application. If you have any questions or need additional information, please contact Paul L. Rinaldo at ARRL headquarters.

Sincerely,

Paul L. Rinaldo, W4RI
Manager, Technical Dept., ARRL

Dr. Thomas A. Clark, W3IWI
President, AMSAT

Letters of Participation for Teleport STA:

Gerald D. Adkins, trustee of WD4IWG (AMRAD)

John R. Biro, K1SKY

Thomas A. Clark, W3IWI

Den Connors, KD2S

Robert J. Diersing, N5AHD

John L. DuBois, W1HDX

David C. Engle, KE6ZE

Gary L. Garriott, WA9FMQ

Sumner M. Hansen, WB6YMH

Lyle V. Johnson, WA7GXD

Philip R. Karn, Jr., KA9Q

John F. Lindholm, trustee of W1AW (ARRL)

Robert S. McCaffrey, KØCY

Harold E. Price, NK6K

William R. Reed, WDØETZ

Vernard Riportella, WA2LQQ

Jose A. Sancho-Dominguez, WB5YFU

Robert S. Stricklin, N5BRG

From fortune!hpda!hplabs!zehntel!ihnp4!msnetp!msweed!rjr Thu May 31 06:30:59 198
Subject: list of English language rtty press stations
Newsgroups: net.ham-radio

The following is a list of frequencies where English language press stations can be found on HF. This list is from personal monitoring over the last 10 years and is not copied from any other lists.

These press stations all transmit in English, some all the time, others just occasionally.

The "SB" column indicates USB or LSB to be selected for normal copy. The apostrophe next to the L or U indicates that the station is still on the air as of the last 12 months. (I don't drop any from the list unless I am sure they are no longer on).

The "SH" column indicates the shift (Mark to Space frequency difference) used. Note that most use 425Hz shift.

The "BD" column indicates the baud rate, not words per minute. This is standard Baudot rtty code. Most foreign stations use "FIGS J" as the bell and "FIGS S" as apostrophe, which is the reverse of American machines.

The "M" in the "BD" column indicates that the station is a frequency division multiplex transmission, usually with 16 subcarriers. The shift is usually 85 Hz and many terminal units will not copy this. Receiving these fdm stations with the bfo off sounds like a buzz-saw. These stations are the best source of AP/UPI news, quite similar in format to the wire line press service sent to radio stations. The best way to tune these in is to select USB, tune onto the station from the high frequency side to the upper-most subcarrier. This subcarrier is usually the one carrying the news.

The "SVC" column shows the abbreviation of the news service.

The "CALL" column is obvious. Not all stations give identify with a call sign. Some use the same call sign on all frequencies at once, and some have calls for each frequency in use, but do not indicate which call is for which transmitter.

Not all stations of a particular service carry the same text. The VOA, for example carries as many as 4 different "programs" at the same time. the ARF, however, has the same text on all 4 frequencies at once.

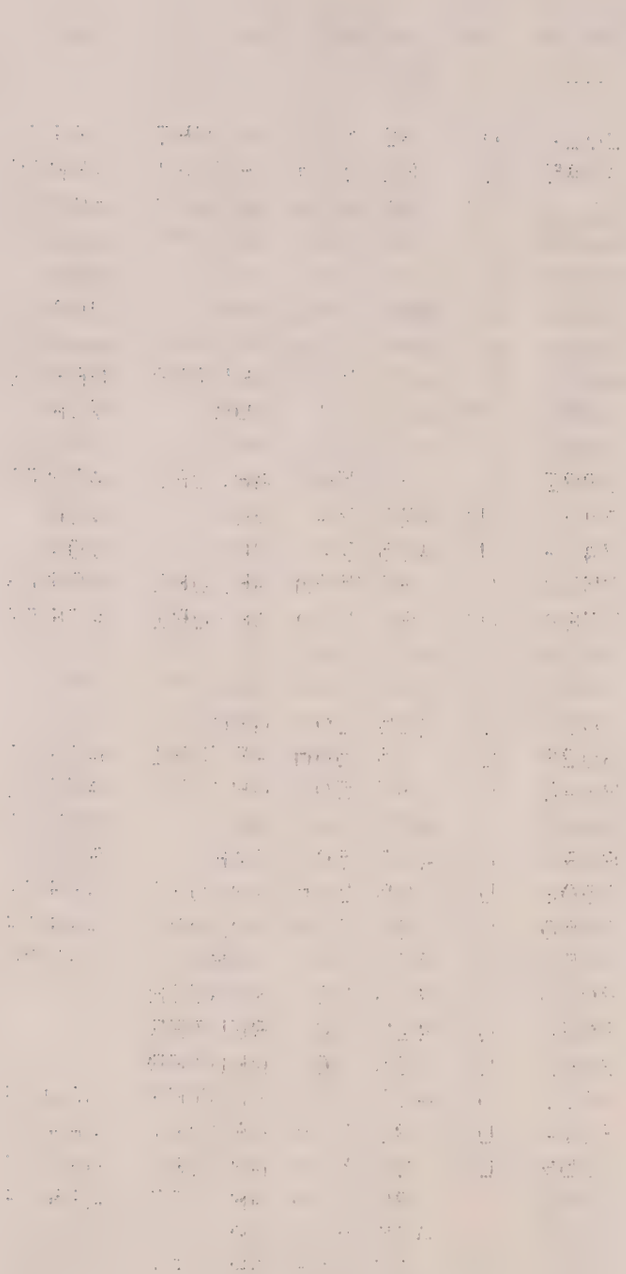
I have not given times of transmissions. That is too difficult to pin down accurately. Many stations are on continuously.

The frequencies given are within 2 kHz. Some stations do slide up or down a little, reverse their mark and space frequencies on occasion, and my receiver readout does not include the amount of bfo offset (about 1.5 kHz).

Later this year, when the list is updated, I will send the complete HF rtty list, including utility stations (weather, military, embassy, etc).

Happy tuning de K9EUI

FREQ	SB	SH	BD	SVC	CALL
2024	U	85	50M	AP/UPI	AFRTS
4045	U'	85	50M	AP/UPI	AFRTS
4515	U'	85	50M	AP/UPI	AFRTS
4620	U'	85	50M	AP/UPI	AFRTS
5435	L'	425	74	VOA	VOA
5460	L'	425	74	VOA	VOA
6834	U'	85	50M	AP/UPI	AFRTS
6853	U	425	50	REUTER	GPE26
6941	U'	170	74	VOA	VOA
6983	U'	425	50	AP	GIC26B
6992	U'	85	50M	AP/UPI	AFRTS
7442	U'	425	74	VOA	VOA
7478	U'	425	74	VOA	VOA
7534	U'	85	50M	AP/UPI	AFRTS
7784	U'	85	50M	AP/UPI	AFRTS
7970	L	425	50	PL	
8000	U'	85	50M	AP/UPI	AFRTS
8022	L'	425	50	AFP	
8029	U'	85	50M	AP/UPI	AFRTS
8148	U	85	50M	AP/UPI	AFRTS
8182	L	425	50	UPI	PDK68
8192	L'	425	50	PAP	SOI31
8506	U'	85	50M	AP/UPI	AFRTS
9050	U'	85	50M	AP/UPI	AFRTS
9053	L'	425	50	ANSA	ISX90
9070	U	425	50	REUTER	
9080	U	425	50	REUTER	
9102	U	425	50	REUTER	
9120	U'	425	50	REUTER	GFN29
9214	U'	85	50M	AP/UPI	AFRTS
9259	U'	85	50M	AP/UPI	AFRTS
9285	U'	85	50M	AP/UPI	AFRTS
9349	U'	425	50	AP	GIC29R
9381	U'	85	50M	AP/UPI	AFRTS
9397	L'	425	50	AFP	FTJ39A
9405	U'	85	50M	AP/UPI	AFRTS
9855	L'	425	74	VOA	VOA
10134	U'	85	50M	AP/UPI	AFRTS
10185	L	425	50	AFP	FPK8
10410	L'	425	74	VOA	VOA
10413	U'	85	50M	AP/UPI	AFRTS
10460	U'	425	74	U.N.	4UZ
10543	L'	425	50	ADN	
10598	U'	425	50	VNA	VNA25
10616	L'	425	50	AFP	FTK61
10648	U'	425	50	AP	GIC30B
10785	L'	425	50	ADN	Y2V43R
10879	U'	425	50	TASS	
10880	U'	425	74	VOA	VOA
10882	L'	425	50	REUTER	



10905	U'	85	50M	AP/UPI	AFRTS
10958	U'	425	50	REUTER	GPE30B
10960	U'	425	50	REUTER	GPE30
10972	L'	425	74	VOA	VOA
10985	U	425	50	BAK	RCB53
11004	U'	85	50M	AP/UPI	AFRTS
11048	U'	85	50M	AP/UPI	AFRTS
11170	L'	425	50	KCNA	
11539	U'	85	50M	AP/UPI	AFRTS
11540	L	425	50	REUTER	GPE30B
11599	U'	85	50M	AP/UPI	AFRTS
11622	U'	425	50	PAP	SOL36
12085	U	425	50	BAK	RCB55
12128	L'	425	50	ANSA	IRJ31
12185	U'	425	50	JANA	
12224	L'	425	74	VOA	VOA
12280	U	425	50	AP	GBU32
13238	U	85	50M	AP/UPI	AFRTS
13410	L	425	50	VNA	VNA16
13438	L'	425	50	DPA	
13460	U'	425	50	VNA	VNA16
13487	L'	425	50	ANSA	ISX35
13490	U	425	50	BAK	RCG77
13493	U	425	50	TASS	RCG77
13504	L	425	50	KCNA	MVS19
13563	U'	850	50	CNA	3MA22
13580	L'	425	50	KCNA	MVS19
13598	L	425	50	CETEKA	
13612	U	425	50	REUTER	
13623	U'	425	50	REUTER	
13625	U'	425	50	REUTER	
13626	U'	425	50	REUTER	
13628	U	425	50	REUTER	
13648	L'	425	50	CETEKA	
13652	U'	425	50	MENA	SUA50
13676	U'	85	50M	AP/UPI	AFRTS
13730	L'	425	50	AFP	
13770	L'	425	74	VOA	VOA
13895	L'	425	50	ADN	Y2V47
13898	L	425	50	ANSA	
13975	L'	425	50	ANSA	ISX19
13995	L'	425	74	VOA	VOA
14360	U	425	50	PAP	
14366	U'	425	50	XINHUA	
14387	U'	85	50M	AP/UPI	AFRTS
14420	U'	85	50M	AERO	AFRTS
14420	U'	85	50M	AP/UPI	AFRTS
14469	U'	425	50	TASS	
14490	U	425	50	TASS	RNK36
14513	U	425	50	REUTER	GPN34
14523	U	425	50	REUTER	GPN34
14525	L'	425	74	VOA	PRS
14547	L	425	50	KYODO	JAL44
14562	U'	85	50M	AP/UPI	AFRTS
14565	U'	425	50	PL	
14568	L	425	50	KCNA	HML61
14572	U'	425	50	JANA	
14631	L'	425	50	ANSA	
14638	L'	425	74	ARF	WFK54
14698	U'	425	50	TASS	REB24
14718	U'	425	50	KYODO	

14720	U	425	50	BAK	RKB58
14762	U	425	50	GNA	
14796	L'	425	50	AFP	
14800	L	425	50	ADN	DMV24
14825	L'	425	50	ADN	Y2V25
14832	U	425	50	KUNA	
14901	L'	425	50	PL	CLN450
14901	L'	425	50	TASS	
14928	L'	425	50	PL	CLN452
14974	U'	425	50	AP	GBW34B
15462	L'	425	50	JANA	
15480	L'	425	50	KCNA	
15482	L'	425	50	AFS	
15506	L'	425	50	CETEKA	
15693	L'	425	50	ANSA	ISX56
15694	L'	425	50	ANSA	ISX56
15743	L'	425	50	VNA	VNA5
15749	U'	85	74	VOA	VOA
15750	U'	85	74	VOA	VOA
15865	U	425	50	BAK	RBK79
15865	U'	425	50	TASS	RRG26
15875	L'	425	74	VOA	VOA
15896	U'	85	50M	AP/UPI	AFRTS
15898	L'	425	50	CETEKA	
15930	U	425	50	BAK	RBI78
15977	L'	425	50	AFP	
15980	L'	425	50	AFP	
15992	U'	425	50	INDFO	WER26
15996	L'	425	50	DPA	
16055	U	425	50	INDFO	WER45
16092	U'	85	50M	AP/UPI	AFRTS
16108	L'	425	50	AFP	
16133	U'	85	50M	AP/UPI	AFRTS
16135	U'	425	50	XINHUA	BZP54
16149	U	425	50	NEWS	
16223	U	850	50	CNA	3MA35
16247	U'	425	50	PL	
16336	U'	425	50	PL	
16342	U'	425	50	TANJUG	YZJ4
16347	U'	425	50	TASS	
16348	U'	425	50	PL	
16348	U'	425	50	TASS	
16380	U'	425	50	PL	
16384	U	425	50	VNA	VNA30
16403	L'	425	50	ADN	Y2V57
16415	L	425	50	ADN	
17210	L	170	74	AFRTS	
17210	U	425	50	XINHUA	
17370	U	425	50	BAK	RBI73
17390	U	425	50	PL	
17393	L'	425	50	PL	CLN565
17415	L	425	50	PL	
17475	L	425	50	PL	
17509	U	425	50	TASS	RFD53
17519	U	425	50	TASS	
17525	L	425	50	CETEKA	OLV3
17545	L'	425	50	AFP	
17552	U	85	50M	AP/UPI	AFRTS
17555	U'	425	50	MAP	CNM73
17564	U'	85	50M	AP/UPI	AFRTS
17565	U	425	50	AP	GIW37B

18005	L	425	50	PL	CLN603
18012	U	425	50	PL	
18050	U'	425	50	TASS	
18101	U'	425	50	REUTER	GPU30
18159	U	425	50	TASS	RTU47
18193	U'	425	50	PL	CLN603
18198	U'	425	50	PL	
18205	U'	85	50M	AP/UPI	AFRTS
18245	U	85	50M	AP/UPI	AFRTS
18261	L'	425	50	KUNA	
18272	U	85	74	VOA	VOA
18292	U	425	50	PL	
18307	L'	425	50	KUNA	
18331	U	425	50	REUTER	
18333	U'	425	50	REUTER	GPE38B
18335	U'	425	50	REUTER	GPE38
18384	U	425	50	TASS	REB24
18392	U'	85	50M	AP/UPI	AFRTS
18434	U'	85	50M	AP/UPI	AFRTS
18519	L'	85	50	AFP	
18540	U	425	50	PL	
18543	L'	425	74	ARF	WFK48
18547	U	425	50	AP	GIY38B
18671	L'	425	50	AFP	FTS67
18675	L	425	50	IINA	
18682	U	425	50	REUTER	
18700	L'	425	50	DPA	
18787	U'	425	50	SUNA	
18824	L'	425	50	ADN	Y2V38A
18835	U'	425	50	TASS	RWN74
18871	U	425	50	XINHUA	
18988	L	425	50	CETEKA	
19148	U	425	50	XINHUA	BAJ29
19162	U'	85	50M	AP/UPI	AFRTS
19171	U'	425	50	MAP	CNM85
19280	L'	425	74	UN	4UZ
19395	U	425	50	JIJI	
19525	L	425	50	CETEKA	OLD4
19565	L'	425	50	ANA	
19818	U'	85	50M	AP/UPI	AFRTS
19825	L	425	50	OANA	
19865	U'	425	74	TANJUG	YZJ4
19975	U	425	50	LPS	
19981	U	425	50	PARS	
20008	U'	425	50	BAKTAR	
20080	L'	425	50	AFP	
20085	L'	425	50	ANSA	ISX20
20100	L	425	50	REUTER	
20105	L'	425	50	DIPLO	HSF212
20110	L	425	50	AFP	
20152	U	85	50M	AP/UPI	AFRTS
20155	L'	425	50	KUNA	
20204	U	425	50	TANJUG	YZJ
20312	L'	425	50	AFP	
20386	U'	425	50	REUTER	
20420	L'	425	50	ADN	Y2V20A
20421	L'	425	50	ADN	
20430	L'	425	50	ANSA	IRS24
20483	L'	425	74	VOA	PRS
20494	U	425	50	PAP	SOV249
20506	U	425	50	KUNA	

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18005 L  425 50  PL          CLN&03
18012 U  425 50  PL
18050 U' 425 50  TASS
18101 U' 425 50  REUTER      DPU30
18139 U  425 50  TASS        RTU&7
18173 U' 425 50  PL          CLN&03
18198 U' 425 50  PL
18205 U'  85 50M APVUPI      AFRTS
18245 U   85 50M APVUPI      AFRTS
18261 L' 425 50  KUNA
18272 U   85 74  UDA         UDA
18292 U  425 50  PL
18307 L' 425 50  KUNA
18331 U  425 50  REUTER
18333 U' 425 50  REUTER      DPE3BP
18335 U' 425 50  REUTER      DPE3B
18384 U  425 50  TASS        RE&Z4
18392 U'  85 50M APVUPI      AFRTS
18434 U'  85 50M APVUPI      AFRTS
18519 L'  85 50  APP
18540 U  425 50  PL
18543 L' 425 74  ARF         NPK4P
18547 U  425 50  AP          GIY3BP
18571 L' 425 50  ARF         FTS&7
18575 L  425 50  IINA
18582 U  425 50  REUTER
18700 L' 425 50  DPA
18757 U' 425 50  SUNA
18824 L' 425 50  AUN         YZV3BA
18835 U' 425 50  TASE        HWN74
18871 U  425 50  XINHUA
18988 L  425 50  CETEKA
19148 U  425 50  XINHUA      BAL2P
19162 U'  85 50M APVUPI      AFRTS
19171 U' 425 50  MAP         CNM&S
19280 L' 425 74  UN          AUZ
19295 U  425 50  JIJI
19325 L  425 50  CETEKA      OLQ4
19365 L' 425 50  ANA
19818 U'  85 50M APVUPI      AFRTS
19825 L  425 50  DANA
19843 U' 425 74  TANJUG      YZJ4
19975 U  425 50  LPS
19981 U  425 50  PARS
20008 U' 425 50  BANTAR
20080 L' 425 50  ARP
20085 L' 425 50  ANSA        I8XZP
20100 L  425 50  REUTER
20105 L' 425 50  DIFLO       H8F2I2
20110 L  425 50  ARP
20132 U   85 50M APVUPI      AFRTS
20185 L' 425 50  KUNA
20294 U  425 50  TANJUG      YZJ
20312 L' 425 50  ARP
20386 U' 425 50  REUTER
20420 L' 425 50  AUN         YZV2DA
20421 L' 425 50  AUN
20430 L' 425 50  ANSA        IP&ZP
20483 L' 425 74  UDA         P&S
20494 U  425 50  PAP         SQV2AP
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20559	U'	425	50	JANA	
20625	U'	85	50M	AP/UPI	AFRTS
20728	L'	425	50	ANSA	IRS27
20776	U'	425	50	INDINFO	
20804	U	425	50	KUNA	
20837	U	85	50M	AP/UPI	AFRTS
21784	L'	425	50	KUNA	
21787	U'	425	50	KUNA	
21801	L	85	74	VOA	VOA
21839	U	425	50	TASS	
22760	U'	425	50	AP	DZK79
22781	U	425	50	TASS	RDD73
22782	L'	425	74	ARF	WFN62
22790	U'	425	50	TASS	
22813	L'	425	50	ADN	Y2V29
22885	L'	425	50	ADN	
22909	U	425	50	KUNA	
22918	U'	85	50M	AP/UPI	AFRTS
22955	L	425	50	ANSA	
23315	U'	85	50M	AP/UPI	AFRTS
23499	U'	85	50M	AP/UPI	AFRTS
23542	U'	425	50	REUTER	GLF43
23751	L	425	50	AFP	
23770	L'	425	74	ARF	WFG93
24029	U'	85	50M	AP/UPI	AFRTS
24089	U	85	50M	AP/UPI	AFRTS
24790	L	425	50	ANSA	ISX24
25377	L'	425	50	ANSA	IRX23

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205?R U' 425 50  JANA
2062S U' 85 50M AP\UP1  AFRTS
2072B L' 425 50  ANSA  TRS2Z
2077A U' 425 50  INTINFO
2080A U  425 50  KUNA
2083Z U  85 50M AP\UP1  AFRTS
2129A L' 425 50  KUNA
2178Z U' 425 50  KUNA
2180I L  85 74  VOA  VOA
2183? U  425 50  TAS5
2276A U' 425 50  AP  DZKZ?
2278I U  425 50  TAS8  RDDZ3
2279Z L' 425 74  ARF  WFN&Z
2279?A U' 425 50  TAS5
2281Z L' 425 50  ADN  YZVZ?
2286S L' 425 50  ADN
2290? U  425 50  KUNA
2291B U' 85 50M AP\UP1  AFRTB
2295E L  425 50  ANSA
2321S U' 85 50M AP\UP1  AFRTS
2349? U' 85 50M AP\UP1  AFRTS
2354Z U' 425 50  REUTER  RLF4J
2375I L  425 50  AFP
2377A L' 425 74  ARF  WF6F?
2402? U' 85 50M AP\UP1  AFRTS
2408? U  85 50M AP\UP1  AFRTS
2479A L  425 50  ANSA  ISX24
2537Z L' 425 50  ANSA  TRX2I
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